

Documentation for 1998 Klamath Ocean Harvest Model

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for
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1 Basic Structure

- The basic overall structure of the Klamath Ocean Harvest Model (KOHM) is depicted in Figure 1. It consists of an age-specific preseason projection of cohort numbers from May 1 through early Sep. Ocean harvest and impact rates (functions of season structure, size limits, shaker mortality rate) are applied to the May 1 numbers to project the number of ocean-fishery survivors. Age-specific maturation rates are then applied to the season’s survivors and these fish constitute the river run. Quota harvests for in-river fisheries are converted to in-river impacts due to dropoff mortality, and the surviving run is projected to be total escapement. A specified fraction of total escapement is taken to occur in natural areas.
- KOHM submodels for the ocean fisheries are described in Section 1.1 and the river fisheries submodel is described in Section 1.2. Estimation of the model parameters is discussed in Section 2.
- The KOHM only models the adult age classes—no accounting of age 2 fish is attempted in the model. Thus, for the ocean fisheries, age 2 harvest and shaker mortality is irrelevant, as is age 2 harvest and dropoff mortality in river fisheries.
- No natural mortality occurs in the projection—that is, it is considered negligible during the May–Sep period relative to other sources of cohort reduction.
- It is proposed that the southern boundary of the KOHM be moved up from the California/Mexican border to Pt. Sur, California. For brood years 1981–1995, there have been but two Klamath Basin CWT fall chinook recovered south of Pt. Sur by the troll fishery. For KOHM accounting purposes, it is proposed that future CWT recoveries south of Pt. Sur be attributed to the southern-most KOHM cell (SOC). This is the convention presently followed for Klamath CWT’s recovered north of Cape Falcon, OR: recoveries off British Columbia and Washington are attributed to the northernmost cell (NOR). Because these tags amount to so few fish, the effects of this consolidation are thought to be insignificant.
- It is noted here that May 1 preseason abundance estimates should *not* be adjusted for the previous fall’s harvest, as these estimates are derived from the relation between the previous fall’s escapement and the May 1 abundance (based on cohort reconstruction).
- Fall ocean harvest (Sep–Oct) is not currently modelled, rather the previous fall’s observed harvest is added to the projected May–Aug harvest to arrive at total ocean harvest for the “biological-year” (Sep–Aug). Under this ageing convention, modelling the upcoming fall’s harvest on a preseason basis would require an estimate of May 1 abundance for age 2 fish in order to predict carryover of these individuals to Sep 1 when they would become age 3. Alternatively, the age designation could be moved forward a few months—these Sep 1 age 3 fish would then be considered old age 2 fish and not within the scope of the KOHM. Sep 1 fish presently considered age 4 and age 5, would then be consider old age 3 and age 4 fish, respectively. Preseason abundance projections are available for these cohorts.
- For documentation on the origins and early development of the KOHM, see KRTAT (1988).

1.1 Ocean Harvest

- All symbolic quantities in this section should be followed by “(a)” to denote age a specificity; e.g., $H(a)$, etc. However, the “(a)” is suppressed for the sake of a “cleaner” presentation. In general, lower case letters will denote rates, proportions, or fractions, while upper case letters will denote absolute numbers. Table 1 lists the symbols used this report. In Section 1, all symbolic quantities are treated as if they were known values. Section 2 deals with estimation of these quantities.
- The ocean fishery submodel is a discrete, time-area model. Time is in months (May, Jun, Jul, Aug), and various fisheries compose the “areas”. Five troll fisheries are included that together span the

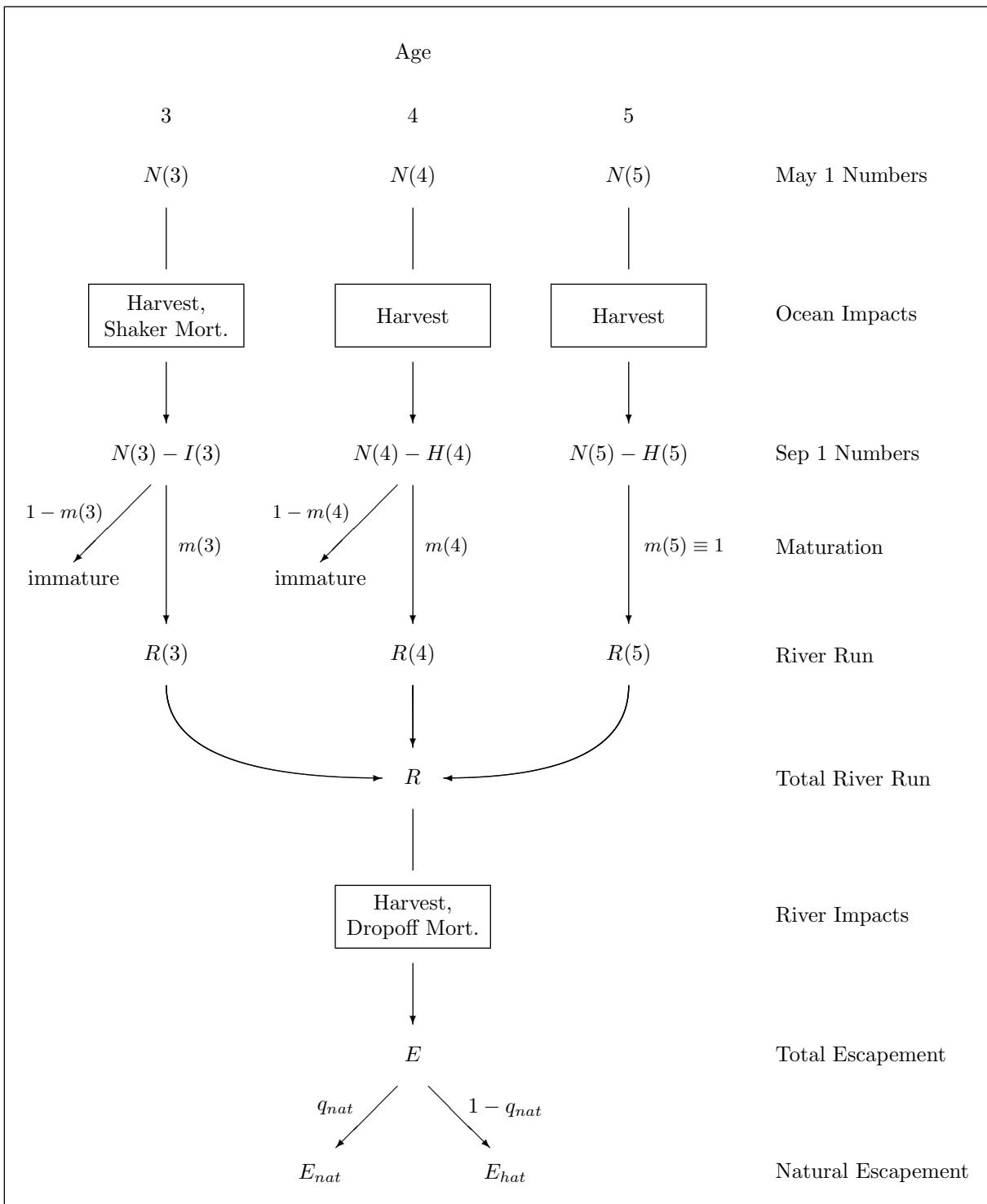


Figure 1: Overview of basic KOHM structure.

Table 1: List of symbols used in this report.

<i>Symbol</i>	<i>Description</i>
a	subscript denoting age, $a \in \{3,4,5\}$
j	subscript denoting area, $j \in \{\text{NOR, CSB, KMZ-T, KMZ-S, FTB, SOC}\}$
k	subscript denoting month, $j \in \{\text{May, Jun, Jul, Aug}\}$
c	contact rate (conditional)
h, u^h	harvest rate: conditional, unconditional
i, u^i	impact rate: conditional, unconditional
s	survival rate in-season (conditional)
p	proportion legal size
r	shaker mortality rate
m	maturation rate (conditional)
d_T, d_S	dropoff rate: tribal, sport (in-river)
q_{nat}	proportion of total escapement spawning in natural areas
f, f^*	fishing effort: general, open-access
p_{days}	proportion of days open to fishing
α	scalar: variously accounts for quotas, effort transfer, and bias-correction
β	contact rate per unit effort
L	length at age
μ, σ^2	length at age parameters: mean, variance
l^*	size limit
n	sample size
N	number alive
C, H, I	contacts, harvest, impacts (ocean)
H_T, H_S	harvest: tribal, sport (in-river)
I_T, I_S	impacts: tribal, sport (in-river)
R	river run
E, E_{nat}, E_{hat}	escapement: total, natural areas, hatchery

West Coast from Cape Falcon, OR to Pt. Sur, CA. From north to south, these fisheries are denoted as NOR=“Northern Oregon”, CSB=“Coos Bay”, KMZ-T=“Klamath Management Zone - Troll”, FTB=“Fort Bragg”, and SOC=“Southern California”. The only sport fishery explicitly recognized is the KMZ-S=“Klamath Management Zone - Sport”. Again, these six fisheries will subsequently be referred to as “areas”, with the understanding that the KMZ-T and KMZ-S fisheries take place within the same latitudinal zone. Figure 2 depicts the area boundaries.

- The ocean harvest submodel is structured as in Figure 3, where the product of the rates along a particular pathway gives the probability of the ultimate event pointed to. Referring to Figure 3, a area-specific contact rate, c_j , $j = \text{NOR}, \dots, \text{SOC}$, is applied to the number (N) alive at the beginning of the month giving the total number “contacted”, or caught, in each area. This “contact” rate c is in fact a compound rate: it is equal to the fraction of fish in that cell times the proportion of them that are caught. Of those that are caught in area j , some fraction p_j are legal-size and thus harvested (H_j). The remaining fraction $1 - p_j$ are sub-legal size and released. Some fraction r_j of these released fish will die from “shaker mortality”. Those fish alive at the beginning of the month that were not contacted, or were sublegal size and survived catch and release, are the number alive at the beginning of the following month. This same structure is used each succeeding month, but the rates are month-specific.
- Age 4 and age 5 fish are considered fully-vulnerable so that for them $p_j \equiv 1$. In this case, the contact, harvest, and impact rate are identical so that $H = I$, and the multi-tiered Figure 3 model reduces to just the first tier (Figure 4).
- All of the rates described above are *conditional* in that they are applied to the number alive at the beginning of the respective month. Note well: for a particular age, N_k represents the *total* number of Klamath Basin fall chinook alive at the beginning of month k —it is not area-specific.
- Dropoff mortality in the ocean fisheries is not explicitly addressed in the KOHM. All that is presently done is to add an additional 5% to the nominal level of shaker mortality for age 3 fish (age 4 and age 5 fish are fully-vulnerable).
- This is not a competing risks model. However, given that the individual component rates governing the process are quite small and the time periods are short, the KOHM approximation to the cohort mortality process is probably satisfactory.

The above relationships can be expressed mathematically as follows. First, all quantities above are month-specific. Thus, for a given age, area j , month k :

$$H_{jk} = N_k \times h_{jk} \quad (1)$$

$$h_{jk} = c_{jk} \times p_{jk} \quad (2)$$

$$I_{jk} = N_k \times i_{jk} \quad (3)$$

$$i_{jk} = c_{jk} [p_{jk} + (1 - p_{jk})r_{jk}] \quad (4)$$

$$N_k = N_{k-1} - I_{k-1}, \quad I_k = \sum_j I_{jk} \quad (5)$$

where h_{jk} and i_{jk} denote the conditional rates of harvest and impact, respectively, given the number (N_k) of fish alive at the beginning of the month. In equation 4 the first term in the square brackets is the fraction of contacts that are legal size and thus harvested, while the second term is the fraction of contacts that sublegal size and die from shaker mortality.

Within month k the impact rates are additive: the fraction of N_k impacted in month k is $i_k = \sum_j i_{jk}$, and the fraction surviving the month is $(1 - i_k)$. The fraction surviving over several months time is the

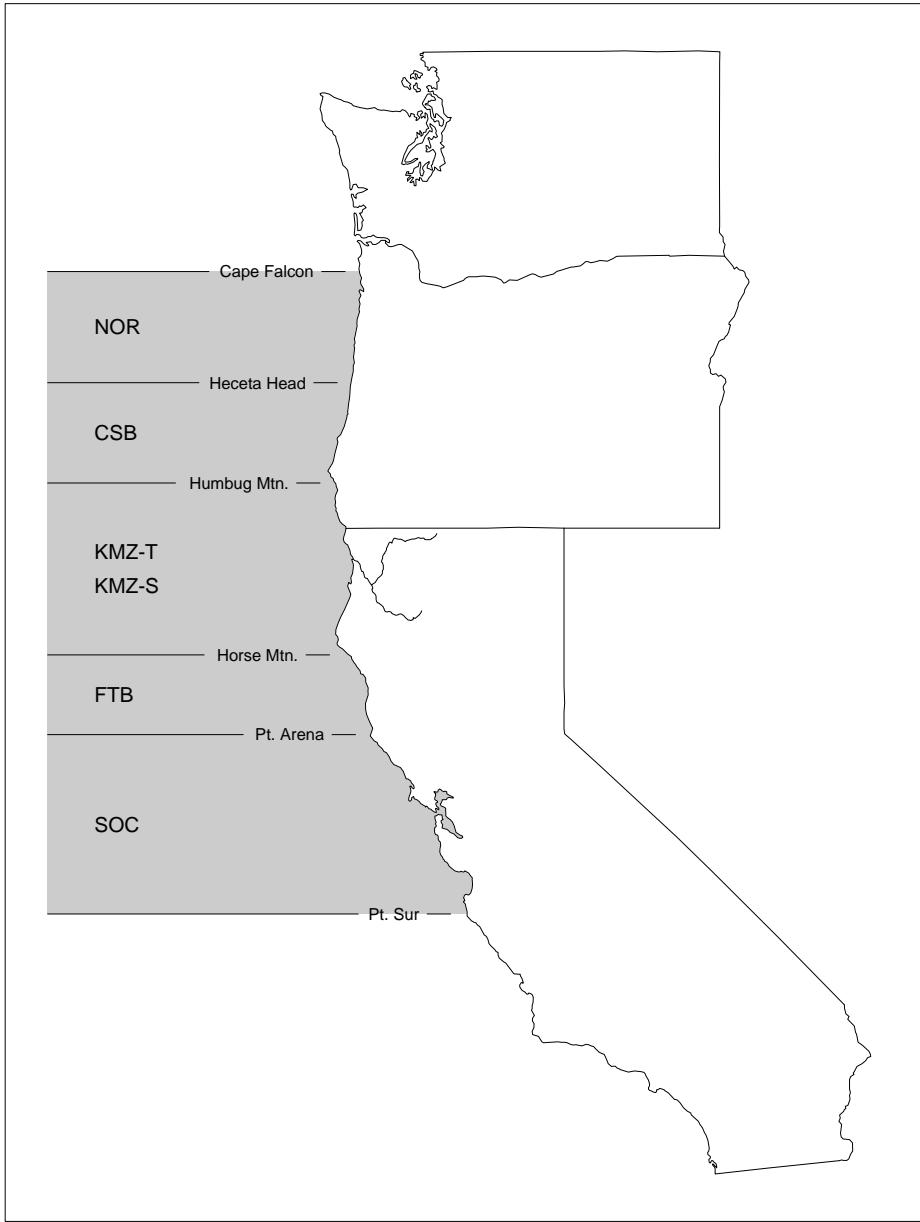


Figure 2: KOHM-designated catch areas for Klamath Basin Fall Chinook. The troll fisheries are denoted: NOR=“Northern Oregon”, CSB=“Coos Bay”, KMZ-T=“Klamath Management Zone - Troll”, FTB=“Fort Bragg”, SOC=“Southern California”. The sport fishery of significance is denoted KMZ-S=“Klamath Management Zone - Sport”.

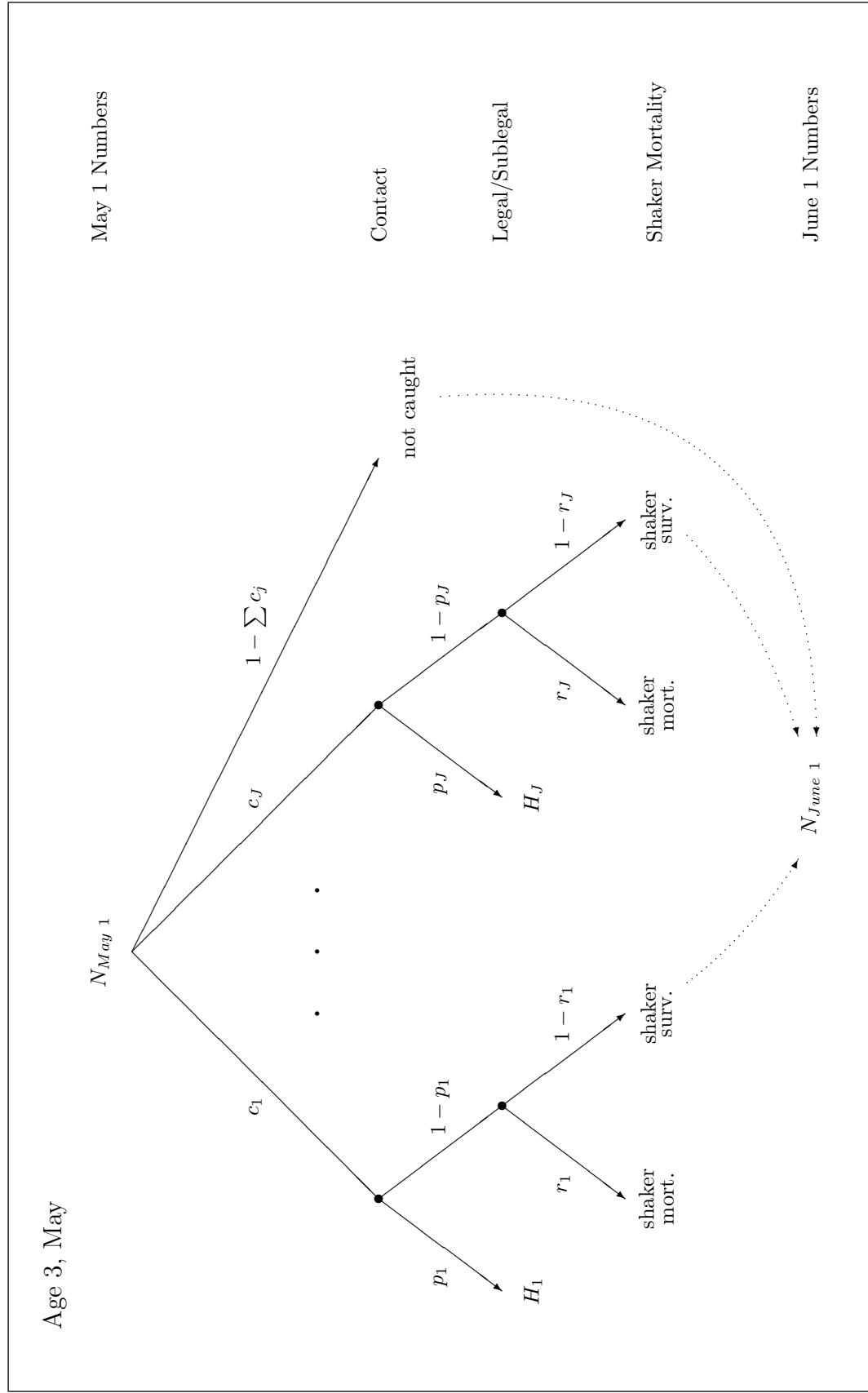


Figure 3: Age 3 ocean harvest model for May. Identical structure for Jun, Jul, and Aug. Subscript j denotes area: 1=NOR, \dots , J =SOC. Month subscript k is suppressed. All quantities age-month specific.

Age 4 and Age 5, May

$N_{May\ 1}$ May 1 Numbers

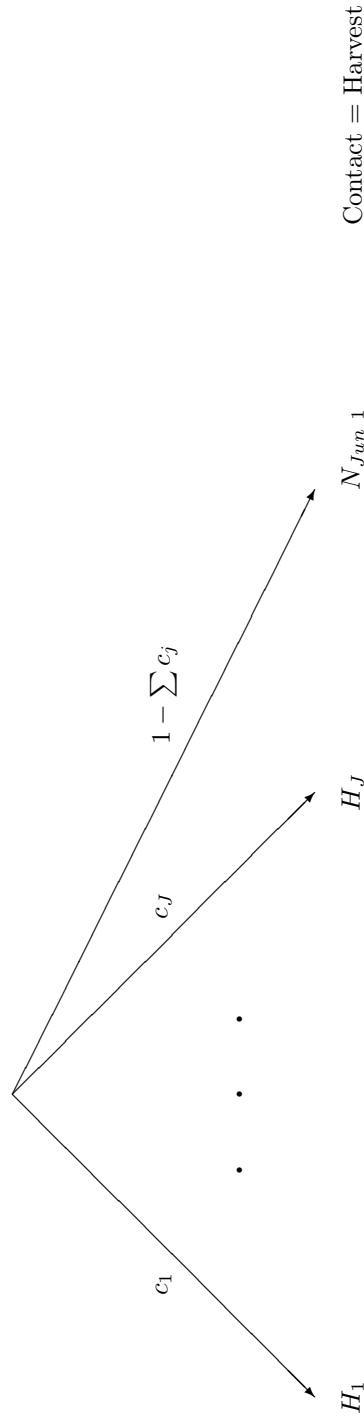


Figure 4: Age 4 and age 5 ocean harvest model for May. Identical structure for Jun, Jul, and Aug. Subscript j denotes area:
 $1=NOR, \dots, J=SOC$. Month subscript k is suppressed. All quantities age-month specific.

product of the monthly survival rates, so that in terms of the May 1 starting numbers:

$$N_k = N_{May} \times s_k \quad (6)$$

$$s_k = \prod_{\alpha=1}^{k-1} (1 - i_\alpha) \quad (7)$$

$$H_{jk} = N_{May} \times u_{jk}^h \quad (8)$$

$$u_{jk}^h = s_k \times h_{jk} \quad (9)$$

$$I_{jk} = N_{May} \times u_{jk}^i \quad (10)$$

$$u_{jk}^i = s_k \times i_{jk} \quad (11)$$

- The rates u_{jk}^h, u_{jk}^i are the cell jk *unconditional* rates of harvest and impact, respectively. They are equal to the fraction of N_1 , rather than N_k , that are harvested and impacted, respectively, in the jk cell. These unconditional rates are of interest because they provide for a direct comparison across all ocean time-area cells, and they also facilitate certain other model computations. However, conditional rates easier to conceptualize, fit, and model as they are independent of past events.
- The various unconditional rates are additive. E.g. for impacts: $u_k^i = \sum_j u_{jk}^i$ and $u^i = \sum_k u_k^i$. The proportion of total impacts attributable to cell jk is thus u_{jk}^i/u^i , and attributable to month k is u_k^i/u^i . Analogous calculations apply for u_{jk}^h .
- For the season as a whole, the impact rate is: $u^i = \sum_{jk} u_{jk}^i = 1 - \prod_k (1 - i_k)$. Therefore, for age a , the ocean impact and maturation model can be summarized as in Figure 5.

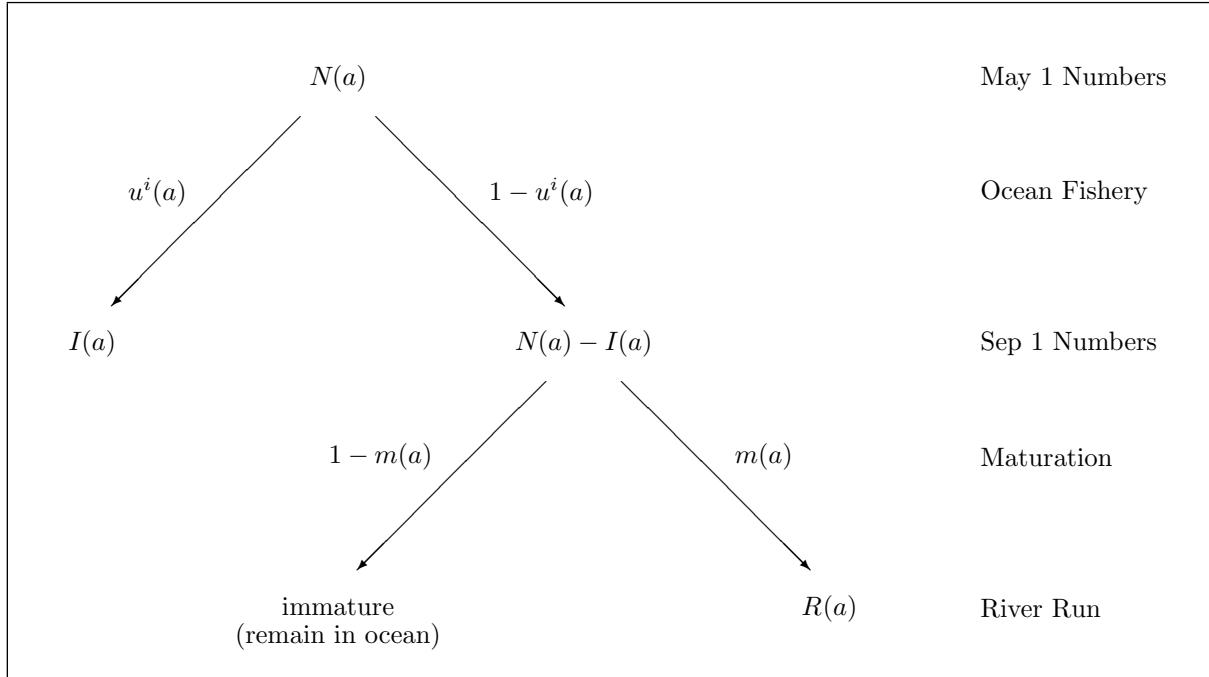


Figure 5: Summary of ocean impacts model and maturation for age a fish.

- Thus, in terms of seasonal rates, May–Aug age-specific harvest, impacts, and river run, along with their respective totals, are given by

$$H(a) = N(a) \times u^h(a), \quad H = \sum_{a=3}^5 H(a) \quad (12)$$

$$I(a) = N(a) \times u^i(a), \quad I = \sum_{a=3}^5 I(a) \quad (13)$$

$$R(a) = N(a) \times (1 - u^i(a)) \times m(a), \quad R = \sum_{a=3}^5 R(a). \quad (14)$$

- For harvest allocation purposes, the previous fall's observed ocean harvest is added to that predicted for May–Aug to estimate the total ocean harvest during the Sep–Aug period (biological year):

$$H_{Sep-Aug} = H_{prev. Fall} + H_{May-Aug} \quad (15)$$

1.1.1 Contact Rate–Effort Relationship

- Contact rates (c) are age-month-area specific, except that they are presumed to be equal for age 4 and 5 fish (as they are fully-vulnerable).
- Contact rate is assumed to be proportional to fishing effort f based on the following. Over a short time period, assuming natural mortality negligible, the standard fishery mortality model provides $c = 1 - e^{-qf}$, or that $-\log(1 - c) = qf$. Because the cell-specific c are expected to be relatively small ($c < .3$), $-\log(1 - c) \approx c$, so that $c \approx qf$. Thus, contact rate is taken to be proportional to effort, with the proportionality constant being age-month-area specific:

$$c = \beta f. \quad (16)$$

1.1.2 Effort–Management Relationship

- This submodel is the major management driver of KOHM. Once the preseason abundances, size-limits, shaker mortality rates, and contact rates per unit of effort are set, the levels of fishing effort are what determines the ocean landings via the relation $c = \beta f$.
- What follows is a description of the effort-management function used in past years. Major revision of this submodel is anticipated prior to KOHM use in 1998 season planning.
- Fundamentally, a proportional relationship has been assumed between effort and days open during the month.
- *Excepting* the SOC, effort within a particular cell has been projected as

$$f = f^* \times p_{days} \times \alpha, \quad (17)$$

where f^* is open-access effort (all fisheries in that month unrestricted), p_{days} is the proportion of days open in the month, and α is an “adjustment” factor that has been used to account for quota fisheries, effort transfer, bias-correction, etc. All of the above quantities have been cell-specific.

- In 1997, the SOC was sub-divided into four zones. From north to south:

1. Pt. Arena — Pt. Reyes
2. Pt. Reyes — Pt. San Pedro

3. Pt. San Pedro — Pigeon Pt.

4. Pigeon Pt. south

- For a particular month, effort within the SOC as a whole was based on the projected effort within each of these zones ($z = 1, 2, 3, 4$):

$$f = \left[\sum_z f_z^* \times p_{z, days} \right] \times \alpha. \quad (18)$$

The zone z unrestricted effort, f_z^* , in turn was expressed as

$$f_z^* = f^* \times p_{z,f} \quad (19)$$

with $p_{z,f}$ denoting the proportion of total SOC effort exerted in zone z in an open-access fishery.

- Thus, in effect, for the SOC as a whole, total f was applied to an SOC-wide β to obtain the expected contact rate. However, f was managed (and predicted) on a sub-cell basis.
- Impacts by sport fisheries other than in the KMZ-S have been shown to be negligible relative to troll impacts—given the troll fishery is operating within a cell. However, if a particular cell was closed to troll fishing but open to sport fishing, equation (17) was applied but with p_{days} and α taking on values specific to the corresponding sport fishery.

1.1.3 Proportion Legal Size

- The subscripts a,j,k are suppressed in the following equations for clarity. The specificity of the various quantities will be made clear within the text.
- It is assumed that total length L is distributed normally with mean μ and variance σ^2 depending on age and month:

$$L \sim N(\mu, \sigma^2). \quad (20)$$

- Under this model, the fraction p of fish that exceed the minimum size limit l^* , at a particular age, month, and area is:

$$p = \Pr\{L \geq l^* | \mu, \sigma^2\} = 1 - \Phi(l^*; \mu, \sigma^2), \quad (21)$$

where $\Phi(\cdot)$ is the cumulative distribution function of L .

- The fraction p is illustrated graphically in Figure 6.
- The parameters μ and σ^2 are age and month dependent, while l^* is area and month dependent, so that p is age-area-month-specific.
- Note: l^* is a management parameter.

1.2 River Harvest

- The river harvest submodel is not age-specific. Its structure is similar to the top two tiers of the age 3 ocean harvest submodel (Figure 3) and is depicted in Figure 7. However, as in-river harvest is managed by quota, tribal and sport harvest, H_T and H_S , are directly specified as inputs rather than as outputs based on a given set of harvest rates.
- In-river fishery impacts are obtained by scaling harvests by their respective “drop-off” rate. In this case, d_T and d_S are defined as the “fraction of fish killed by the respective fisheries, but not harvested”.

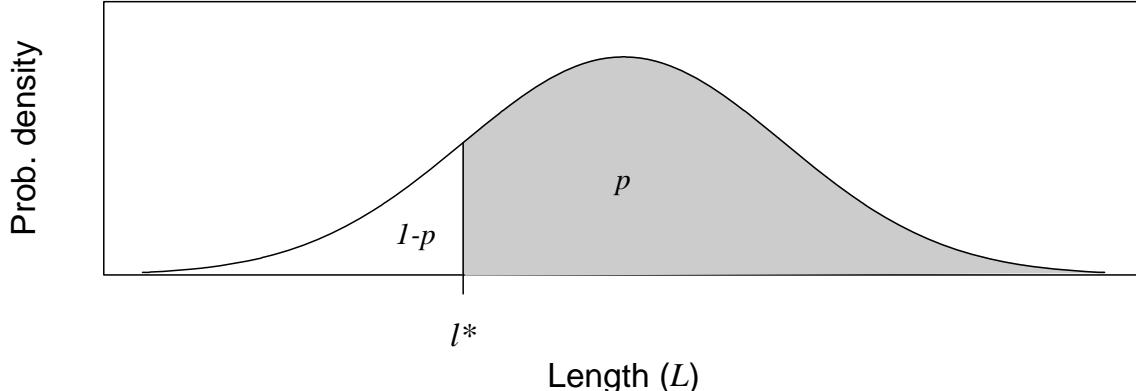


Figure 6: Graphical depiction of the proportion p of legal size fish as a function of the size limit l^* . The management parameter l^* is area-month-specific, so that p is age-area-month-specific.

$$I_T = H_T / (1 - d_T) \quad (22)$$

$$I_S = H_S / (1 - d_S) \quad (23)$$

- Total spawning escapement is the number returning to the river less in-river impacts:

$$E = R - I_T - I_S, \quad (24)$$

- From the proportion of E expected to spawn in natural areas, q_{nat} , the total number of adult spawners in natural areas is given by

$$E_{nat} = E \times q_{nat}. \quad (25)$$

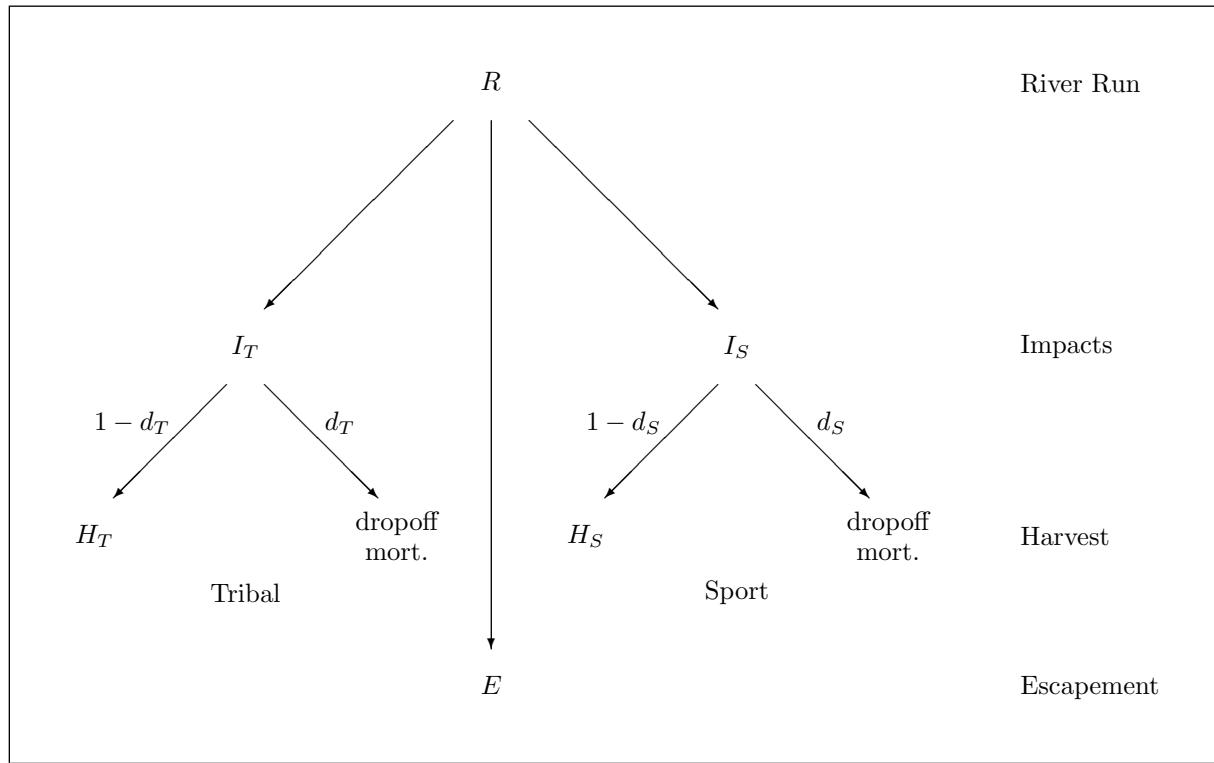


Figure 7: In-river harvest model. Not age specific.

2 Parameter Estimates

2.1 Proportion Legal Size

- Data: Klamath River Basin fall chinook CWT ocean troll and ocean sport recoveries, by age, month, and fishery, calendar years 1986–1996.
- Only lengths greater than or equal to the minimum size limit are present in ocean recoveries. That is, recovery lengths have a truncated distribution (lower limit = size limit) relative to the population of fish at large. Thus, for recovery i , $\{l_i, l_i^*\}$ is observed, where l_i is total length (in), and l_i^* is the size limit in place for that fishery at that time.
- For most years and areas in 1986–1996 period, the minimum size limit was 26" for troll fisheries, and 20" for sport fisheries. Occasionally, however, size limits of 0", 24", and 27" were in effect.
- Interannual variability in the size at age data was not examined (it cannot be incorporated into the KOHM unless correlated with auxiliary data measurable on a preseason basis).
- For a given age and month, L is assumed to be normally distributed with density $\phi(\cdot)$ and cumulative distribution function $\Phi(\cdot)$. Observation $\{l_i, l_i^*\}$ thus has density $\phi(l_i)/[1 - \Phi(l_i^*)]$, so that the log-likelihood of the data for μ and σ^2 is

$$\sum_i [\log\{\phi(l_i; \mu, \sigma^2)\} - \log\{1 - \Phi(l_i^*; \mu, \sigma^2)\}], \quad (26)$$

with μ and σ^2 possibly dependent on age, month, and fishery.

- Maximum likelihood estimates (mle's) of μ and σ^2 were obtained by numerically maximizing equation (26). Likelihood ratio tests were used to assess the significance of the dependence of μ and σ^2 on age, month, and fishery. Because of the large sample sizes involved, tests were conducted at the $\alpha = .01$ level.
- *Age 3 and 4 analysis.* Initially, the data were examined separately by age and month. For each age-month, differences between troll and sport mean length were tested (assuming equal variance). For age 3, no significant differences within months were found, but for age 4 in July and August, the sport mean length was significantly greater than troll mean length. A follow-up analysis indicated that month-specific estimates of σ^2 were not statistically different between ages 3 and 4. Therefore, μ was considered age and month dependent (troll and sport differing only at age 4 in July and August), with σ^2 dependent on month but not age.
- *Age 5 analysis.* Substantially less data was available to examine the distribution of length at age 5, precluding an examination of within-month differences between the troll and sport fisheries. On pooling the troll and sport data, the month-specific mle's of μ showed an increasing pattern over the summer similar to that for age 3 and 4, but the estimate for May was deemed to be too low—much less than that obtained for age 4 fish in August. Therefore, for May only, it was assumed that the percentage of August–June growth occurring in May–June was the same as that for age 4 fish, and $\mu_{5,May}$ was estimated accordingly as

$$\hat{\mu}_{5,May} = \hat{\mu}_{5,Jun} - \hat{b}_4 \times (\hat{\mu}_{5,Jun} - \hat{\mu}_{4,Aug}), \quad (27)$$

where $\hat{b}_4 = (\hat{\mu}_{4,Jun} - \hat{\mu}_{4,May})/(\hat{\mu}_{4,Jun} - \hat{\mu}_{3,Aug})$.

- Due to small sample sizes, the estimates of variance by month were considered unreliable, so the age independent values estimated from the age 3 and 4 data were used to represent age 5 as well.
- The resulting estimates of μ and σ^2 are given in Table 2.

Table 2: Maximum-likelihood estimates of mean and variance ($\hat{\mu}, \hat{\sigma}^2$) of total length (in), by age and month. $\hat{\sigma}^2$ is month-specific, but age-independent. Mean length at age 4 in July and August estimated separately for troll (T) and sport (S) fisheries. For age 5 fish in May, mean length was estimated based on over-winter growth rate of age 4 fish (see equation 27). The fitted distributions of length at age appear as smooth curves in Figures 8, 9, and 10. Database consisted of all ocean recovered fall chinook CWT fish, 1986–1996, originating from the Klamath River Basin.

<i>Month</i>	$\hat{\mu}_3$	$\hat{\mu}_4$	$\hat{\mu}_5$	$\hat{\sigma}^2$
May	26.2	30.2	33.6	5.11
Jun	26.7	31.2	34.1	5.40
Jul	27.3	T=32.4/S=32.8	34.6	5.78
Aug	27.8	T=32.4/S=33.8	35.3	6.29

- For each age 3, 4, and 5, histograms of the raw data by month and fishery are shown in Figures 8, 9, and 10, respectively. The smooth curves superimposed over these histograms depict the corresponding estimated distributions.
- Table 3 lists the estimated proportion legal for a 26" size limit, by age and month.

Table 3: Estimated proportion (\hat{P}) of fish greater than or equal to 26", by age and month. Assumes length is normally distributed, with means and variances as given in Table 2. For all ages and months, $\hat{P}(L \geq 20") = 1.0$.

<i>Month</i>	$\hat{P}(L_3 \geq 26")$	$\hat{P}(L_4 \geq 26")$	$\hat{P}(L_5 \geq 26")$
May	0.54	0.97	1.00
Jun	0.62	0.99	1.00
Jul	0.71	1.00	1.00
Aug	0.76	1.00	1.00

- Figure 11 depicts the estimated relationship between the proportion legal p and minimum size limit l^* for age 3 fish, by month.

2.2 Contact Rate—Effort Relationship

Contact rates are estimated as follows.

- Data: All Klamath River Basin fall chinook CWT releases (fingerling, yearling, . . .), brood years (BY) 1982–1991. (BY91 is the most recent brood which has completed its life-cycle as of Sep 30, 1997.) Releases pooled within brood year—one cohort per brood year. Raw CWT recoveries expanded *only* for sampling—not for production multipliers, hatchery/natural production ratios, etc.

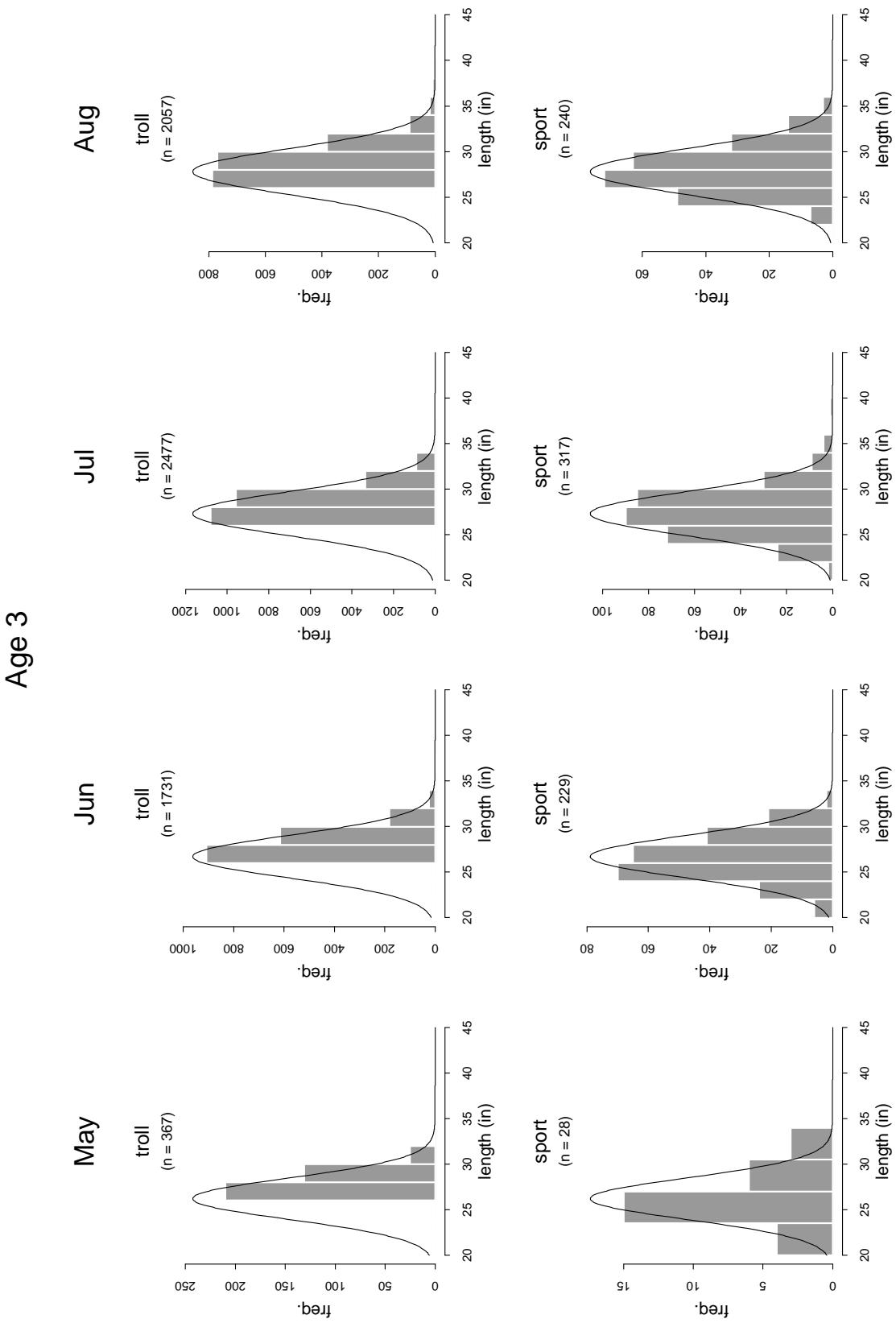


Figure 8: Age 3 length frequency histograms, by month and fishery. Smooth curve is fitted normal density (see Table 2 for means and variances). Data includes all legal-size age 3 ocean recovered fall chinook CWT fish (not expanded for sampling), calendar years 1986–1996, of Klamath Basin origin. Sample size in parentheses.

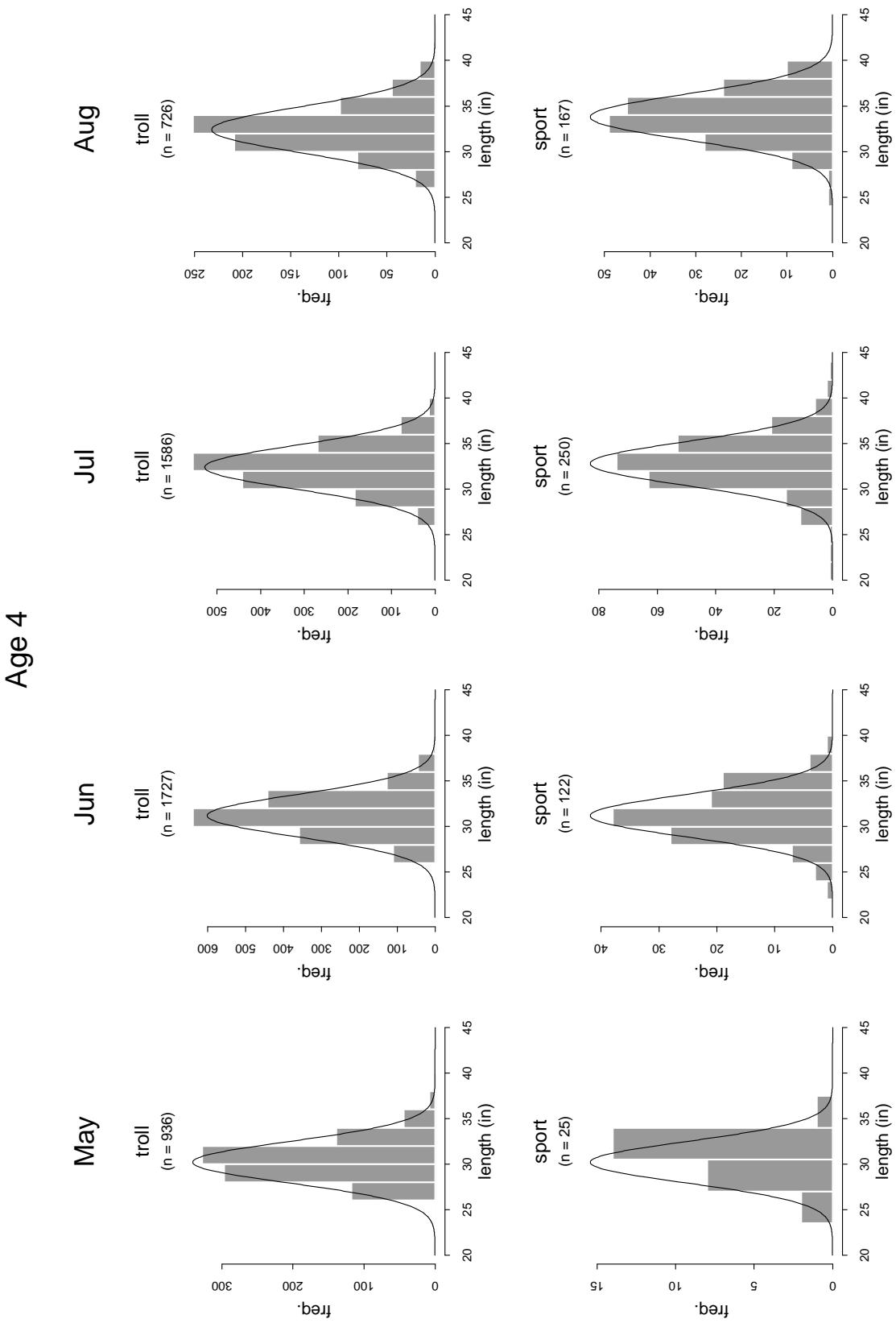


Figure 9: Age 4 length frequency histograms, by month and fishery. Smooth curve is fitted normal density (see Table 2 for means and variances). Data includes all legal-size age 4 ocean recovered fall chinook CWT fish (not expanded for sampling), calendar years 1986–1996, of Klamath Basin origin. Sample size in parentheses.

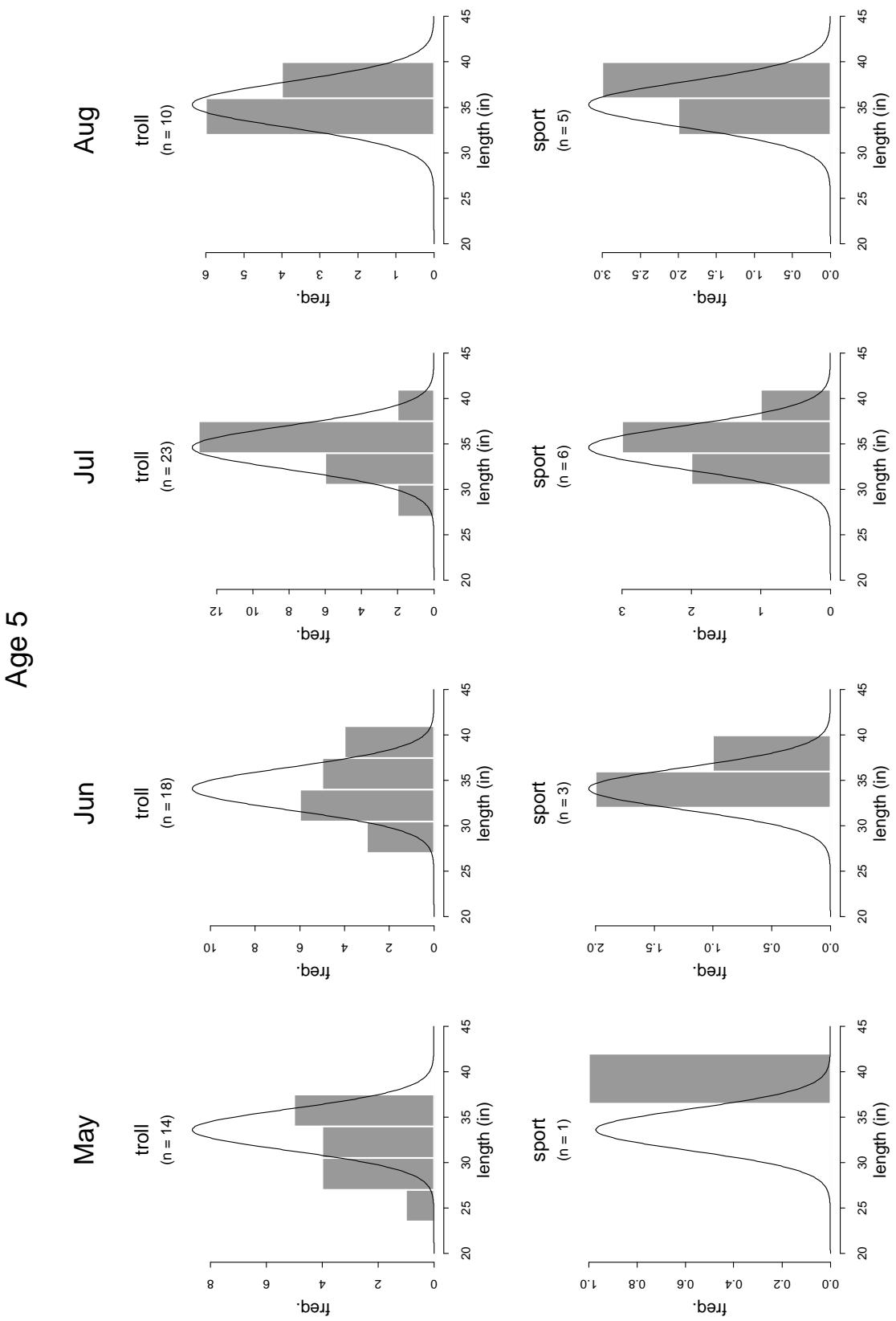


Figure 10: Age 5 length frequency histograms, by month and fishery. Smooth curve is fitted normal density (see Table 2 for means and variances). Data includes all legal-size age 5 ocean recovered fall chinook CWT fish (not expanded for sampling), calendar years 1986–1996, of Klamath Basin origin. Sample size in parentheses.

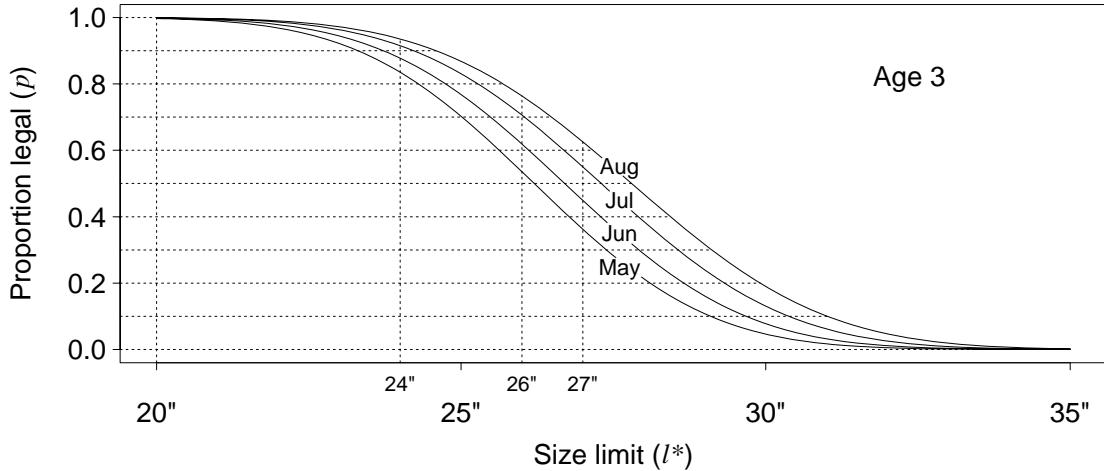


Figure 11: Graphical depiction of age 3 proportion legal size (p) as a function of the size limit (l^*), by month.

- Basic cohort reconstruction carried out separately for each brood year. Age convention: fish turn age “ a ” just after Sep 1, and remain age a through Sep 1 of the year following. Mature fish are assumed to leave the ocean for spawning Sep 1. Natural mortality is assumed to be 20% annually for adults, and is applied at the end of the fall ocean harvest period.
- The cohort reconstruction is essentially a reverse application of the cohort projection model developed earlier in Section 1.1. The same notation is adopted here, but reference now is to a single cohort across years, rather than multi-age cohorts within a particular year.
- Determining the rates of contact, impact, and harvest, requires estimation of the associated numerators and base denominators. First the numerators. For a particular age a , area j , and month k , the numbers of contacts (C) and impacts (I) were derived from the observed harvest (H) as (see equations 1–5):

$$C = H \times (c/h) = H/p \quad (28)$$

$$I = H \times (i/h) = (H/p) \times [p + (1 - p)r + d] \quad (29)$$

where the subscript $\{ajk\}$ has been omitted from all of the terms above for clarity. In equation (29), the first term in the square brackets accounts for landed catch, the second term accounts for shaker impacts, and the third term accounts for dropoff impacts.

- The multipliers c/h and i/h were determined by substituting into the equations above the relevant p estimates obtained in the previous section, along with $r = 0.26$ and $d = 0.05$. Age 4 and 5 fish in the Fall (Sept), were assumed to have the same length distribution as fish the preceding month (Aug). The resulting conversion multipliers are given in Table 4. (Recall that the KOHM does not evaluate harvest impacts on age 2 fish.)
- The relevant denominators are obtained by reconstructing cohort numbers backwards in time, accounting for river returns (R), ocean impacts (I), and natural mortality. The reconstructive sequence is depicted in Figure 12. Note that N_{ak} refers to the number of age a fish alive at the *beginning* of month k , whereas I_{ak} refers to the number of impacts of age a fish *during* month k . $N_{a,Sep'}$ refers to the number of age a fish remaining in the ocean just following the departure of mature fish on Sep 1.

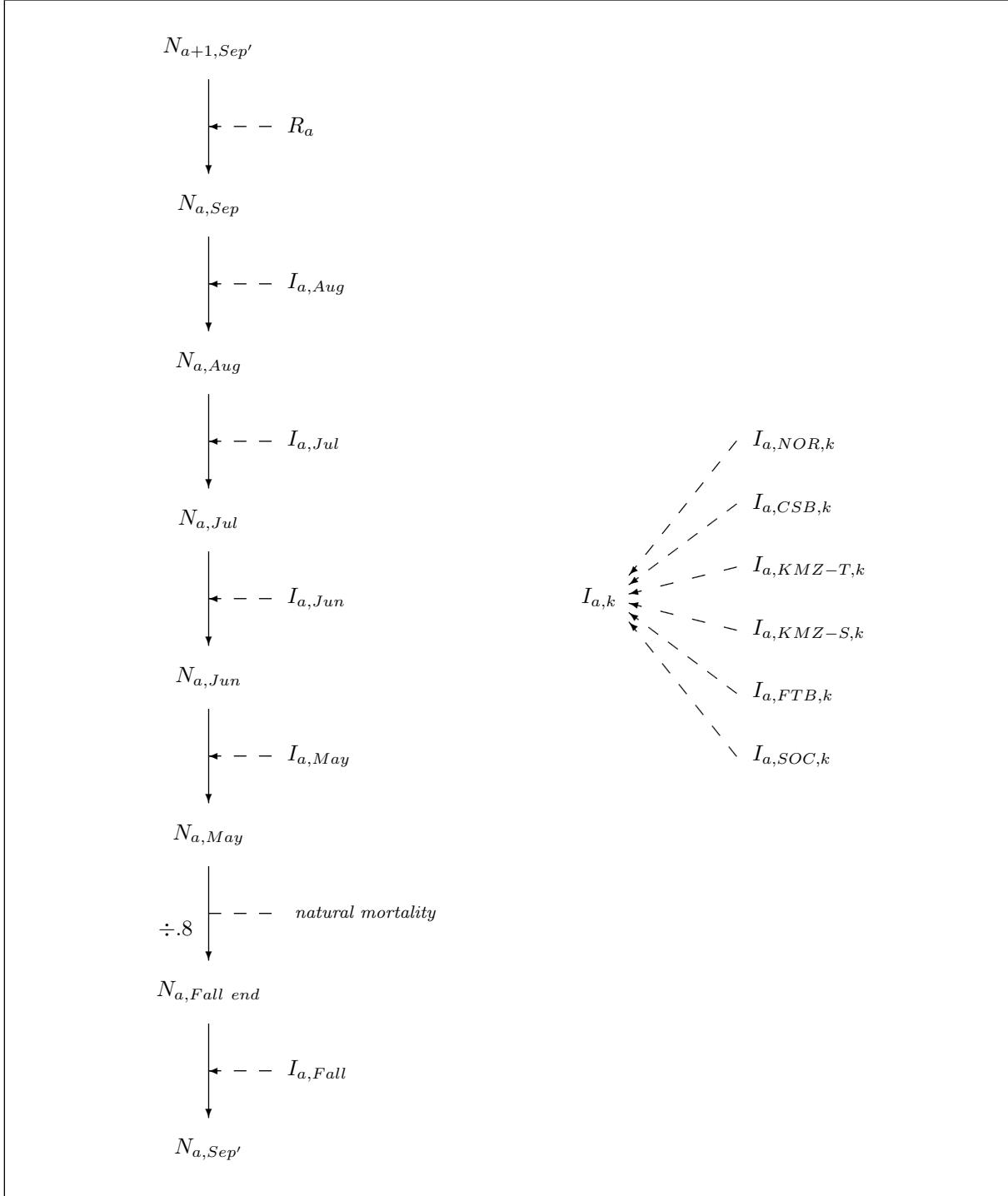


Figure 12: CWT cohort reconstructive sequence. Subscript a denotes age; $a = 5, 4, 3$. Klamath River fall chinook rarely exceed 5 years of age, so that the reconstruction initializes with $N_{6,Sep'} \equiv 0$ and proceeds toward younger ages as indicated. $N_{a,k}$ denotes number alive at the *beginning* of month k , except for $N_{a,Sep'}$ which denotes number remaining in the ocean just following escapement (typically early September). R_a is the number that mature and return to the river. $I_{a,k}$ denotes the total number of impacts *during* month k ; it being the sum of area-specific impacts as shown on the right-side of the graphic. Natural mortality is accounted for during the period between the end of the Fall fisheries and May 1 the year following—it is assumed to be a constant 20% for age 4 and 5 fish.

Table 4: Multipliers used to convert CWT ocean troll harvest caught under a 26" size limit into CWT ocean troll contacts (c/h) = $1/p$, and ocean troll impacts (i/h), respectively (rounded to two decimal places). These multipliers are defined in terms of the proportion of legal-size fish p , the shaker mortality rate $r = 0.26$, and the drop-off mortality rate $d = 0.05$, as given by equations (28) and (29). Values used for p are maximum likelihood (Table 3). Age 4 and 5 fish in the Fall (Sept), were assumed to have the same length distribution as fish the preceding month (Aug). For the sport fishery with a 20" size limit, age 3, 4, and 5 fish are fully vulnerable so that $(c/h) = 1.00$ and $(i/h) = 1.05$, for all ages and months.

	Age 3		Age 4		Age 5	
Month	c/h	i/h	c/h	i/h	c/h	i/h
Fall	—	—	1.31	1.15	1.00	1.05
May	1.87	1.32	1.03	1.06	1.00	1.05
Jun	1.62	1.24	1.01	1.05	1.00	1.05
Jul	1.42	1.18	1.00	1.05	1.00	1.05
Aug	1.31	1.15	1.00	1.05	1.00	1.05

- Referring to Figure 12, to determine the number alive at the beginning of a time period during the fishing season, the number alive in the following time period are added to the total number of impacts during the time period. The calculation proceeds in this manner, initializing with $N_{6,Sep'} \equiv 0$ and working backwards to $N_{3,May}$. The calculations are summarized for age $a = 3, 4, 5$ as:

$$N_{a,Sep} = N_{a+1,Sep'} + R_a \quad (30)$$

$$N_{a,k} = N_{a,k+1} + I_{a,k}, \quad k = Aug, Jul, Jun, May \quad (31)$$

$$N_{a,Sep'} = (N_{a,May}/.8) + I_{a,Fall} \quad (32)$$

- The graphic on the right hand side of Figure 12 indicates that the age a impacts in month k are the sum of the area-specific impacts I_{ajk} , and that the relevant numerator for the age a area-specific impacts, contacts, and harvest in month k is N_{ak} . Thus, based on the coded wire tag data, the observed rates of contact, impact, and harvest are given respectively by:

$$c_{ajk} = \frac{C_{ajk}}{N_{ak}}, \quad i_{ajk} = \frac{I_{ajk}}{N_{ak}}, \quad h_{ajk} = \frac{H_{ajk}}{N_{ak}} \quad (33)$$

- The estimated age 3 and age 4 rates for calendar years 1986–1994 and 1986–1995, respectively, are listed in Appendix A.
- Age 5 rates are not shown as they are considered too unreliable because of small sample size. The age 5 rates are assumed to have been the same as the age 4 rates over the years in question as they were both, for practical purposes, fully vulnerable to all fisheries.
- The estimated contact rates are plotted against the respective observed effort in Figures 13 (age 3) and 14 (age 4). Units of fishing effort are 1000's of days fished for the troll fishery (PFMC, 1997, Tables A-2, A-7, A-20), and 1000's of angler trips for the KMZ-S (PFMC, 1997, Table A-22). The observed fishing effort is not age-specific so that $f_{ajk} = f_{jk}$.
- The line shown in each plot is the ratio estimator fit to the assumed proportional relationship between c and f . The line is anchored at the *known* point (0,0), and the slope is estimated as

Age 3

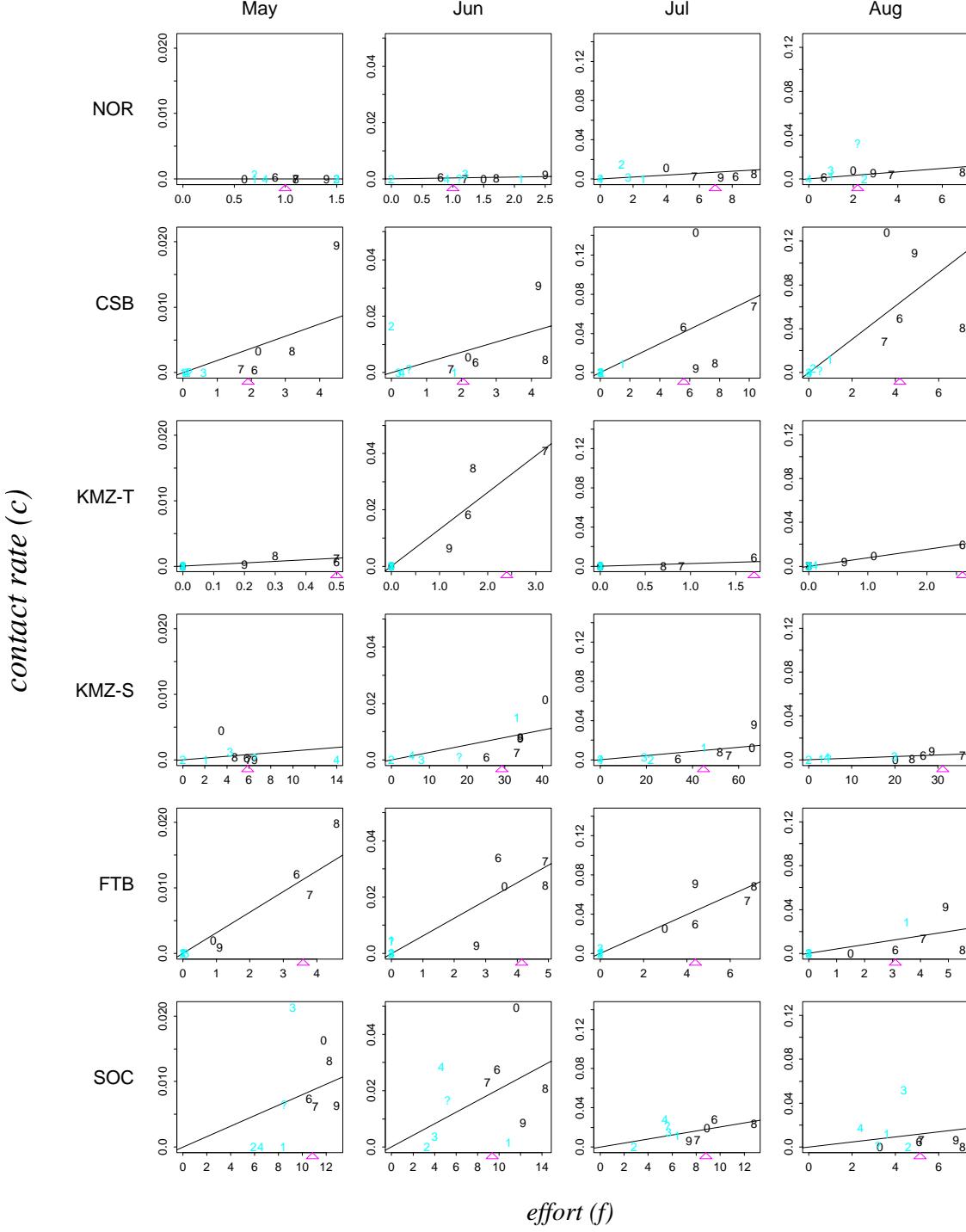


Figure 13: Age 3 CWT contact rates versus fishing effort: area by month, CY86–94. Vertical scale constant within a month. Horizontal scale floats with observed range of effort. CY86–90 estimates in black; CY91–94 in blue. Number plotted is second digit of calendar year; e.g. CY86=“6”, CY93=“3”. CY95 preliminary estimate denoted by “?”. Slope of linear fit through origin is ratio estimate. Ave{ f } for CY86–87 indicated by \triangle (indicates CY86 f for CSB,KMZ-T,FTB in Jul,Aug). See text for further explanation and discussion.

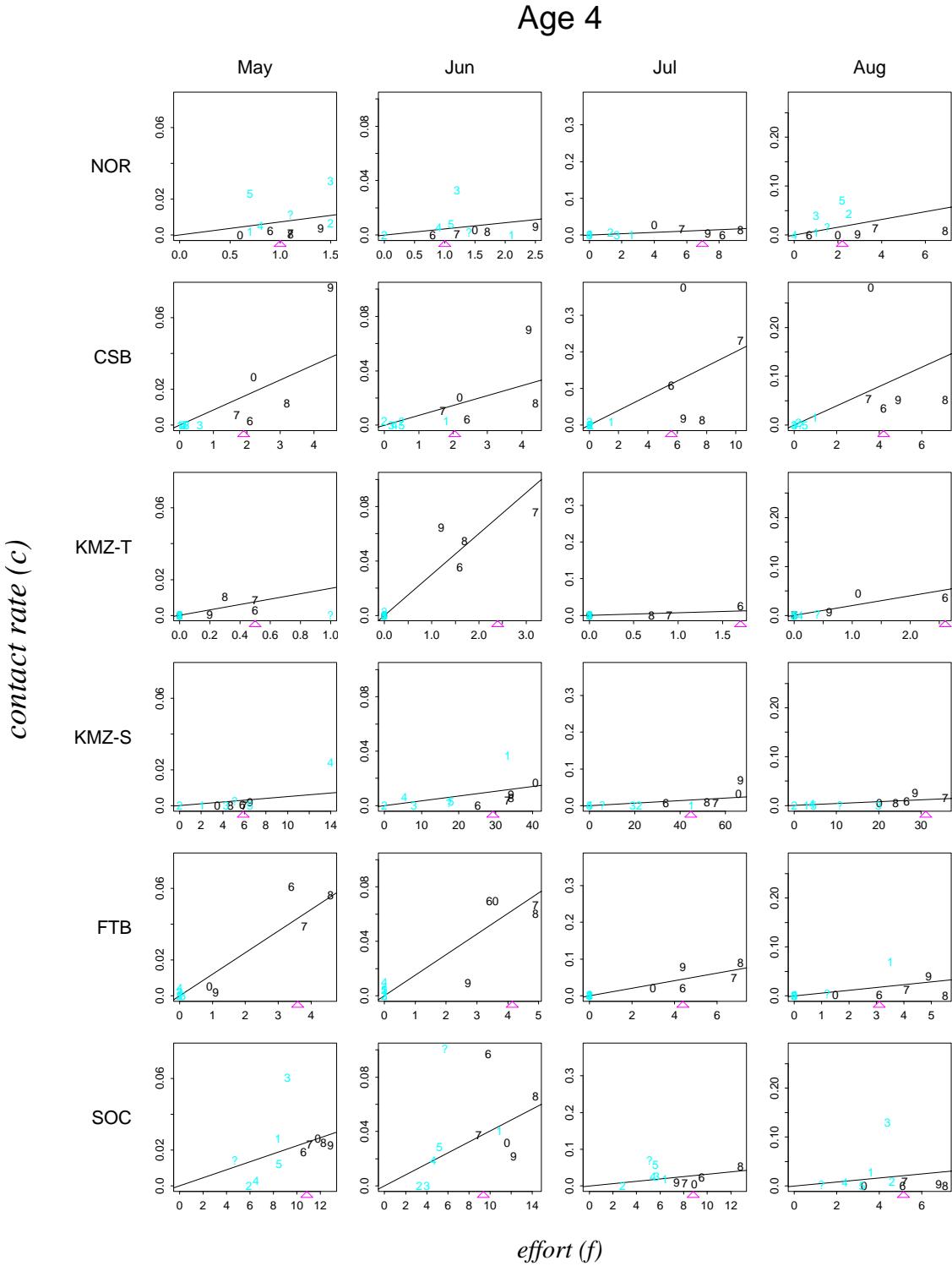


Figure 14: Age 4 CWT contact rates versus fishing effort: area by month, CY86–95. Vertical scale constant within a month. Horizontal scale floats with observed range of effort. CY86–90 estimates in black; CY91–95 in blue. Number plotted is second digit of calendar year; e.g. CY86=“6”, CY93=“3”. CY96 preliminary estimate denoted by “?”. Slope of linear fit through origin is ratio estimate. Ave{ f } for CY86–87 indicated by \triangle (indicates CY86 f for CSB,KMZ-T,FTB in Jul,Aug). See text for further explanation and discussion.

$$\hat{\beta}_{ajk} = \frac{ave\{c_{ajk}\}}{ave\{f_{jk}\}} \quad (34)$$

where the average is taken over calendar years.

- $\hat{\beta}$ weights each data point equally with respect to sample size (and thus calendar year), but assumes that the variance displayed in c increases in proportion to f , which appears to be the case for these data. Under these conditions, $\hat{\beta}$ is minimum-variance amongst all unbiased estimators for β . (Use of the least-squares estimator for β would assume a constant variance in c across the range of f which clearly is incompatible with these data.)
- While there is scatter about the line in these plots, and occasionally large outliers, the data appear to be consistent with the proportional hypothesis.
- There also does not appear to be any strong evidence of a north-south distributional shift in abundance in later years. Were that the case, in later years one would expect to see a preponderance of negative residuals in the northern cells, and positive residuals in the southern cells (and vice-versa for the earlier years).
- The interrelationships displayed among the Figure plots are quite consistent between age 3 and age 4.
- The respective $\hat{\beta}$ and associated $ave\{f_{jk}\}$ are listed in Appendix B.

2.3 Effort—Management Relationship

- Effort prediction is the key to successful application of the KOHM.
- What follows is in part a description of the way in which effort-management parameters were arrived at in 1997, and in part a description of how these strategies would fit into the KOHM as described in this report. Major revision of the effort-management submodel and estimation of its parameters are anticipated prior to KOHM use in 1998 season planning.
- In principal, open-access (“base-period”) fishing effort f^* for each cell should be estimated as the mean effort observed for the two calendar years 1986 and 1987, as opposed to CY86–90. The mean should be restricted to these two years because beginning in 1988, there were significant closures in the various cells, resulting in a redistribution of fishing effort. In fact, in 1987, the KMZ-T was closed all of July and August, with the result that much of that effort transferred to the CSB and FTB cells. Thus, for the FTB, CSB, and KMZ-T cells, f^* should be estimated as the 1986 observed level of effort. The f^* based on the referred to averages are indicated by the Δ symbol in Figures 13 and 14.
- The main management link to the KOHM has been p_{days} ; the fraction of days open to fishing in the particular cell-month. If a season opening was pushed forward into April, that additional effort was lumped into the May cell. Thus, p_{days} for May may have been set to a value exceeding 1; e.g. for a fishery open April 15–May 31, $p_{days} = 1.5$.
- The value of α has been pivotal, but too varied outside of the SOC to discuss thoroughly here, other than to say that in the *absence* of a troll fishery and presence of a sport fishery, $\alpha = .03$ for FTB and $\alpha = .20$ for SOC.
- For the SOC in 1997, $p_{z,f}$ was determined as follows. It was assumed that total chinook catch in the SOC (all stocks) was proportional to effort in the SOC during the 1986–90 period. For this period, 29% (144.8/495.9) of the SOC chinook catch was landed in the Major Port of Monterey (PFMC, 1997, Table A-3). Thus, 29% of open-access effort in the SOC was ascribed to zone 4; Pigeon Pt. south. It was assumed that the remaining 71% of the SOC effort was distributed according to relative size of the remaining zones, as measured by latitude range. Table 5 shows how the $p_{z,f}$ values were calculated for each zone.

Table 5: Proportion ($p_{z,f}$) of open-access total SOC effort attributed to each zone for the 1997 projection. Proportion ascribed based on latitude range, and CY86–90 average annual landings in the two Major Port Areas of the SOC: Monterey (29%) and San Francisco (71%).

<i>Zone</i>	<i>N. Bound. Lat.</i>	<i>Lat. Range</i>	<i>Range/108'</i>	$p_{z,f}$
1: Pt. Arena — Pt. Reyes	38° 58'	58'	0.54	$0.71 \times 0.54 = 0.38$
2: Pt. Reyes — Pt. San Pedro	38° 00'	24'	0.22	$0.71 \times 0.22 = 0.16$
3: Pt. San Pedro — Pigeon Pt.	37° 36'	26'	0.24	$0.71 \times 0.24 = 0.17$
4: Pigeon Pt. south	37° 10'	—	—	$0.29 \times 1.00 = 0.29$
		108'	1.00	

- For the SOC in 1997, the α were set to $1.63 \times (1.12, 1.17, 1.28, 1.00)$, respectively, for May, Jun, Jul, Aug. Prior to 1997, the factors inside the parenthesis were intended to account for effort shift into the SOC resulting from closure of the FTB fishery. (These factors were reset to 1 in 1995 in recognition of diminished effort transfer, but were reinstated in 1996 when it became clear that SOC impacts were underpredicted in 1995.) In 1997, the 1.63 scalar was applied on top of these factors to adjust for the KOHM's substantial underestimation of SOC impacts throughout the 1990's. The 1.63 scalar was calculated as the average observed harvest rate of adults in the SOC over the CY91,93–96 period as determined from CWT data, divided by the average adult harvest rate over the same period as predicted by the KOHM (absent the 1.63 scalar).

3 Appendix A

Table 6: Age 3 CWT contact rates (c), harvest rates (h), impact rates (i), and fishing effort (f), calendar years (CY) 1986–1995 (1995 estimates are preliminary). Estimated rates are area-month specific. Corresponding proportion legal size p and shaker mortality rate r are listed. The numerators for the c , h , and i estimates are given under C , H , and I , respectively. These are all equivalent for the KMZ-S because $p = 1$ (and hence the value of r is immaterial: $r = “-”$). The denominator in each case is N . See text for explanation of calculations. Fishing effort is in terms of 1000's of days fished for the troll fishery (PFMC, 1997, Tables A-2, A-7, A-20), and 1000's of angler trips for the KMZ-S (PFMC, 1997, Table A-22).

Age 3												
CY	Area	Month	p	r	C	H	I	N	c	h	i	f
86	NOR	May	0.57	0.31	14	8	10	62867	0.00022325	0.00012725	0.00015701	0.9
86	NOR	Jun	0.62	0.31	29	18	21	61938	0.00046873	0.00029061	0.00034583	0.8
86	NOR	Jul	0.70	0.31	147	103	117	58069	0.00253393	0.00177375	0.00200940	8.2
86	NOR	Aug	0.78	0.31	65	51	55	52636	0.00124220	0.00096892	0.00105363	0.7
86	CSB	May	0.57	0.31	25	14	17	62867	0.00039069	0.00022269	0.00027477	2.1
86	CSB	Jun	0.62	0.31	213	132	157	61938	0.00343738	0.00213118	0.00253610	2.4
86	CSB	Jul	0.70	0.31	2721	1905	2158	58069	0.04686533	0.03280573	0.03716421	5.6
86	CSB	Aug	0.78	0.31	2612	2037	2215	52636	0.04961496	0.03869967	0.04208341	4.2
86	KMZ-T	May	0.57	0.31	39	22	27	62867	0.00061394	0.00034994	0.00043178	0.5
86	KMZ-T	Jun	0.62	0.31	1131	701	834	61938	0.01825457	0.01131783	0.01346822	1.6
86	KMZ-T	Jul	0.70	0.31	500	350	397	58069	0.00861043	0.00602730	0.00682807	1.7
86	KMZ-T	Aug	0.78	0.31	1021	796	866	52636	0.01938808	0.01512270	0.01644497	2.6
86	KMZ-S	May	1.00	—	14	14	14	62867	0.00022269	0.00022269	0.00022269	5.8
86	KMZ-S	Jun	1.00	—	51	51	51	61938	0.00082341	0.00082341	0.00082341	25.2
86	KMZ-S	Jul	1.00	—	78	78	78	58069	0.00134323	0.00134323	0.00134323	33.8
86	KMZ-S	Aug	1.00	—	183	183	183	52636	0.00347670	0.00347670	0.00347670	26.6
86	FTB	May	0.57	0.31	758	432	533	62867	0.01205549	0.00687163	0.00847863	3.4
86	FTB	Jun	0.62	0.31	2098	1301	1548	61938	0.03387903	0.02100500	0.02499595	3.4
86	FTB	Jul	0.70	0.31	1747	1223	1385	58069	0.03008730	0.02106111	0.02385923	4.4
86	FTB	Aug	0.78	0.31	167	130	141	52636	0.00316639	0.00246979	0.00268574	3.1
86	SOC	May	0.57	0.31	467	266	328	62867	0.00742306	0.00423114	0.00522064	10.6
86	SOC	Jun	0.62	0.31	1703	1056	1257	61938	0.02749904	0.01704941	0.02028879	9.8
86	SOC	Jul	0.70	0.31	1637	1146	1298	58069	0.02819300	0.01973510	0.02235705	9.5
86	SOC	Aug	0.78	0.31	258	201	219	52636	0.00489573	0.00381867	0.00415256	5.1
87	NOR	May	0.57	0.31	0	0	0	40949	0.00000000	0.00000000	0.00000000	1.1
87	NOR	Jun	0.62	0.31	0	0	0	40463	0.00000000	0.00000000	0.00000000	1.2
87	NOR	Jul	0.70	0.31	111	78	88	37445	0.00297581	0.00208307	0.00235982	5.7
87	NOR	Aug	0.78	0.31	122	95	103	33391	0.00364759	0.00284512	0.00309389	3.7
87	CSB	May	0.57	0.31	19	11	14	40949	0.00047127	0.00026862	0.00033144	1.7
87	CSB	Jun	0.62	0.31	52	32	38	40463	0.00127555	0.00079084	0.00094110	1.7
87	CSB	Jul	0.70	0.31	2523	1766	2001	37445	0.06737536	0.04716275	0.05342866	10.3
87	CSB	Aug	0.78	0.31	926	722	785	33391	0.02772169	0.02162291	0.02351353	3.5
87	KMZ-T	May	0.57	0.31	51	29	36	40949	0.00124244	0.00070819	0.00087381	0.5
87	KMZ-T	Jun	0.62	0.31	1661	1030	1226	40463	0.04105677	0.02545519	0.03029168	3.2
87	KMZ-T	Jul	0.70	0.31	0	0	0	37445	0.00000000	0.00000000	0.00000000	0.9
87	KMZ-T	Aug	0.78	0.31	0	0	0	33391	0.00000000	0.00000000	0.00000000	0.0
87	KMZ-S	May	1.00	—	0	0	0	40949	0.00000000	0.00000000	0.00000000	6.0
87	KMZ-S	Jun	1.00	—	97	97	97	40463	0.00239724	0.00239724	0.00239724	33.3
87	KMZ-S	Jul	1.00	—	172	172	172	37445	0.00459343	0.00459343	0.00459343	55.8
87	KMZ-S	Aug	1.00	—	138	138	138	33391	0.00413291	0.00413291	0.00413291	35.7
87	FTB	May	0.57	0.31	367	209	258	40949	0.00895414	0.00510386	0.00629745	3.8
87	FTB	Jun	0.62	0.31	1324	821	977	40463	0.03272583	0.02029001	0.02414512	4.9
87	FTB	Jul	0.70	0.31	2000	1400	1586	37445	0.05341195	0.03738836	0.04235568	6.8
87	FTB	Aug	0.78	0.31	438	342	372	33391	0.01313132	0.01024243	0.01113799	4.1
87	SOC	May	0.57	0.31	254	145	179	40949	0.00621220	0.00354096	0.00436904	11.1
87	SOC	Jun	0.62	0.31	923	572	681	40463	0.02280046	0.01413628	0.01682218	8.9
87	SOC	Jul	0.70	0.31	261	183	207	37445	0.00698170	0.00488719	0.00553649	8.1
87	SOC	Aug	0.78	0.31	208	162	176	33391	0.00622010	0.00485168	0.00527589	5.2
88	NOR	May	0.57	0.31	0	0	0	21648	0.00000000	0.00000000	0.00000000	1.1
88	NOR	Jun	0.62	0.31	5	3	4	21064	0.00022971	0.00014242	0.00016948	1.7
88	NOR	Jul	0.70	0.31	106	74	84	19579	0.00539928	0.00377950	0.00428163	9.3
88	NOR	Aug	0.78	0.31	105	82	89	17764	0.00591804	0.00461607	0.00501968	6.9

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Age 3

CY	Area	Month	p	r	C	H	I	N	c	h	i	f
88	CSB	May	0.57	0.31	72	41	51	21648	0.00332266	0.00189392	0.00233683	3.2
88	CSB	Jun	0.62	0.31	98	61	73	21064	0.00467080	0.00289590	0.00344612	4.4
88	CSB	Jul	0.70	0.31	189	132	150	19579	0.00963115	0.00674180	0.00763750	7.7
88	CSB	Aug	0.78	0.31	733	572	622	17764	0.04128192	0.03219990	0.03501533	7.1
88	KMZ-T	May	0.57	0.31	33	19	23	21648	0.00153977	0.00087767	0.00108292	0.3
88	KMZ-T	Jun	0.62	0.31	735	456	543	21064	0.03491616	0.02164802	0.02576115	1.7
88	KMZ-T	Jul	0.70	0.31	0	0	0	19579	0.00000000	0.00000000	0.00000000	0.7
88	KMZ-T	Aug	0.78	0.31	0	0	0	17764	0.00000000	0.00000000	0.00000000	0.0
88	KMZ-S	May	1.00	—	9	9	9	21648	0.00041574	0.00041574	0.00041574	4.7
88	KMZ-S	Jun	1.00	—	170	170	170	21064	0.00807053	0.00807053	0.00807053	34.2
88	KMZ-S	Jul	1.00	—	150	150	150	19579	0.00766114	0.00766114	0.00766114	51.9
88	KMZ-S	Aug	1.00	—	18	18	18	17764	0.00101328	0.00101328	0.00101328	24.0
88	FTB	May	0.57	0.31	428	244	301	21648	0.01977388	0.01127111	0.01390697	4.6
88	FTB	Jun	0.62	0.31	506	314	374	21064	0.02404315	0.01490675	0.01773903	4.9
88	FTB	Jul	0.70	0.31	1343	940	1065	19579	0.06858545	0.04800981	0.05438826	7.1
88	FTB	Aug	0.78	0.31	56	44	48	17764	0.00317553	0.00247692	0.00269349	5.5
88	SOC	May	0.57	0.31	284	162	200	21648	0.01312856	0.00748328	0.00923332	12.3
88	SOC	Jun	0.62	0.31	437	271	322	21064	0.02075062	0.01286538	0.01530980	14.3
88	SOC	Jul	0.70	0.31	463	324	367	19579	0.02364009	0.01654806	0.01874659	12.8
88	SOC	Aug	0.78	0.31	0	0	0	17764	0.00000000	0.00000000	0.00000000	7.1
89	NOR	May	0.57	0.31	0	0	0	8123	0.00000000	0.00000000	0.00000000	1.4
89	NOR	Jun	0.62	0.31	11	7	8	7970	0.00141663	0.00087831	0.00104519	2.5
89	NOR	Jul	0.70	0.31	11	8	9	7616	0.00150061	0.00105043	0.00118998	7.3
89	NOR	Aug	0.78	0.31	35	27	29	6834	0.00506550	0.00395109	0.00429656	2.9
89	CSB	May	0.57	0.31	158	90	111	8123	0.01943829	0.01107983	0.01367095	4.5
89	CSB	Jun	0.62	0.31	245	152	181	7970	0.03076100	0.01907182	0.02269547	4.2
89	CSB	Jul	0.70	0.31	37	26	29	7616	0.00487699	0.00341389	0.00386745	6.4
89	CSB	Aug	0.78	0.31	745	581	632	6834	0.10900208	0.08502162	0.09245557	4.9
89	KMZ-T	May	0.57	0.31	2	1	1	8123	0.00021598	0.00012311	0.00015190	0.2
89	KMZ-T	Jun	0.62	0.31	52	32	38	7970	0.00647600	0.00401512	0.00477799	1.2
89	KMZ-T	Jul	0.70	0.31	0	0	0	7616	0.00000000	0.00000000	0.00000000	0.0
89	KMZ-T	Aug	0.78	0.31	27	21	23	6834	0.00393983	0.00307307	0.00334177	0.6
89	KMZ-S	May	1.00	—	0	0	0	8123	0.00000000	0.00000000	0.00000000	6.5
89	KMZ-S	Jun	1.00	—	60	60	60	7970	0.00752835	0.00752835	0.00752835	34.2
89	KMZ-S	Jul	1.00	—	276	276	276	7616	0.03623977	0.03623977	0.03623977	66.6
89	KMZ-S	Aug	1.00	—	54	54	54	6834	0.00790218	0.00790218	0.00790218	28.6
89	FTB	May	0.57	0.31	7	4	5	8123	0.00086392	0.00049244	0.00060760	1.1
89	FTB	Jun	0.62	0.31	23	14	17	7970	0.00283325	0.00175662	0.00209037	2.7
89	FTB	Jul	0.70	0.31	543	380	430	7616	0.07127905	0.04989533	0.05652428	4.4
89	FTB	Aug	0.78	0.31	290	226	246	6834	0.04240012	0.03307209	0.03596378	4.9
89	SOC	May	0.57	0.31	51	29	36	8123	0.00626345	0.00357017	0.00440508	12.9
89	SOC	Jun	0.62	0.31	68	42	50	7970	0.00849975	0.00526985	0.00627112	12.2
89	SOC	Jul	0.70	0.31	47	33	37	7616	0.00619002	0.00433302	0.00490869	7.4
89	SOC	Aug	0.78	0.31	41	32	35	6834	0.00600356	0.00468277	0.00509222	6.8
90	NOR	May	0.57	0.31	0	0	0	2685	0.00000000	0.00000000	0.00000000	0.6
90	NOR	Jun	0.62	0.31	0	0	0	2632	0.00000000	0.00000000	0.00000000	1.5
90	NOR	Jul	0.70	0.31	27	19	22	2423	0.01120392	0.00784275	0.00888471	4.0
90	NOR	Aug	0.78	0.31	15	12	13	2010	0.00765462	0.00597060	0.00649265	2.0
90	CSB	May	0.57	0.31	9	5	6	2685	0.00326720	0.00186230	0.00229782	2.2
90	CSB	Jun	0.62	0.31	15	9	11	2632	0.00551497	0.00341928	0.00406895	2.2
90	CSB	Jul	0.70	0.31	346	242	274	2423	0.14270260	0.09989182	0.11316316	6.4
90	CSB	Aug	0.78	0.31	256	200	217	2010	0.12757694	0.09951002	0.10821076	3.6
90	KMZ-T	May	0.57	0.31	0	0	0	2685	0.00000000	0.00000000	0.00000000	0.0
90	KMZ-T	Jun	0.62	0.31	0	0	0	2632	0.00000000	0.00000000	0.00000000	0.0
90	KMZ-T	Jul	0.70	0.31	0	0	0	2423	0.00000000	0.00000000	0.00000000	0.0
90	KMZ-T	Aug	0.78	0.31	19	15	16	2010	0.00956827	0.00746325	0.00811581	1.1
90	KMZ-S	May	1.00	—	12	12	12	2685	0.00446953	0.00446953	0.00446953	3.5
90	KMZ-S	Jun	1.00	—	56	56	56	2632	0.02127554	0.02127554	0.02127554	40.8
90	KMZ-S	Jul	1.00	—	31	31	31	2423	0.01279606	0.01279606	0.01279606	65.8
90	KMZ-S	Aug	1.00	—	0	0	0	2010	0.00000000	0.00000000	0.00000000	20.1
90	FTB	May	0.57	0.31	5	3	4	2685	0.00196032	0.00111738	0.00137869	0.9
90	FTB	Jun	0.62	0.31	63	39	46	2632	0.02389821	0.01481689	0.01763210	3.6

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Age 3

CY	Area	Month	p	r	C	H	I	N	c	h	i	f
90	FTB	Jul	0.70	0.31	61	43	49	2423	0.02535625	0.01774937	0.02010750	3.0
90	FTB	Aug	0.78	0.31	0	0	0	2010	0.00000000	0.00000000	0.00000000	1.5
90	SOC	May	0.57	0.31	44	25	31	2685	0.01633599	0.00931151	0.01148910	11.8
90	SOC	Jun	0.62	0.31	131	81	96	2632	0.04963475	0.03077355	0.03662052	11.6
90	SOC	Jul	0.70	0.31	47	33	37	2423	0.01945945	0.01362161	0.01543134	8.9
90	SOC	Aug	0.78	0.31	0	0	0	2010	0.00000000	0.00000000	0.00000000	3.3
91	NOR	May	0.57	0.31	0	0	0	2125	0.00000000	0.00000000	0.00000000	0.7
91	NOR	Jun	0.62	0.31	0	0	0	2125	0.00000000	0.00000000	0.00000000	2.1
91	NOR	Jul	0.70	0.31	0	0	0	2083	0.00000000	0.00000000	0.00000000	2.6
91	NOR	Aug	0.78	0.31	4	3	3	2025	0.00189893	0.00148117	0.00161067	1.0
91	CSB	May	0.57	0.31	0	0	0	2125	0.00000000	0.00000000	0.00000000	0.0
91	CSB	Jun	0.62	0.31	0	0	0	2125	0.00000000	0.00000000	0.00000000	1.8
91	CSB	Jul	0.70	0.31	17	12	14	2083	0.00822876	0.00576013	0.00652541	1.5
91	CSB	Aug	0.78	0.31	24	19	21	2025	0.01202656	0.00938071	0.01020093	1.0
91	KMZ-T	May	0.57	0.31	0	0	0	2125	0.00000000	0.00000000	0.00000000	0.0
91	KMZ-T	Jun	0.62	0.31	0	0	0	2125	0.00000000	0.00000000	0.00000000	0.0
91	KMZ-T	Jul	0.70	0.31	0	0	0	2083	0.00000000	0.00000000	0.00000000	0.0
91	KMZ-T	Aug	0.78	0.31	0	0	0	2025	0.00000000	0.00000000	0.00000000	0.0
91	KMZ-S	May	1.00	—	0	0	0	2125	0.00000000	0.00000000	0.00000000	2.1
91	KMZ-S	Jun	1.00	—	32	32	32	2125	0.01506021	0.01506021	0.01506021	33.3
91	KMZ-S	Jul	1.00	—	25	25	25	2083	0.01200028	0.01200028	0.01200028	44.9
91	KMZ-S	Aug	1.00	—	2	2	2	2025	0.00098744	0.00098744	0.00098744	2.9
91	FTB	May	0.57	0.31	0	0	0	2125	0.00000000	0.00000000	0.00000000	0.0
91	FTB	Jun	0.62	0.31	10	6	7	2125	0.00455450	0.00282379	0.00336031	0.0
91	FTB	Jul	0.70	0.31	0	0	0	2083	0.00000000	0.00000000	0.00000000	0.0
91	FTB	Aug	0.78	0.31	58	45	49	2025	0.02848395	0.02221748	0.02416009	3.5
91	SOC	May	0.57	0.31	0	0	0	2125	0.00000000	0.00000000	0.00000000	8.4
91	SOC	Jun	0.62	0.31	3	2	2	2125	0.00151817	0.00094126	0.00112010	10.9
91	SOC	Jul	0.70	0.31	24	17	19	2083	0.01165741	0.00816019	0.00924433	6.4
91	SOC	Aug	0.78	0.31	23	18	20	2025	0.01139358	0.00888699	0.00966403	3.6
92	NOR	May	0.57	0.31	0	0	0	682	0.00000000	0.00000000	0.00000000	1.5
92	NOR	Jun	0.62	0.31	0	0	0	682	0.00000000	0.00000000	0.00000000	0.0
92	NOR	Jul	0.70	0.31	10	7	8	674	0.01483449	0.01038414	0.01176375	1.3
92	NOR	Aug	0.78	0.31	0	0	0	666	0.00000000	0.00000000	0.00000000	2.5
92	CSB	May	0.57	0.31	0	0	0	682	0.00000000	0.00000000	0.00000000	0.1
92	CSB	Jun	0.62	0.31	11	7	8	682	0.01654418	0.01025739	0.01220629	0.0
92	CSB	Jul	0.70	0.31	0	0	0	674	0.00000000	0.00000000	0.00000000	0.1
92	CSB	Aug	0.78	0.31	3	2	2	666	0.00384899	0.00300221	0.00326472	0.2
92	KMZ-T	May	0.57	0.31	0	0	0	682	0.00000000	0.00000000	0.00000000	0.0
92	KMZ-T	Jun	0.62	0.31	0	0	0	682	0.00000000	0.00000000	0.00000000	0.0
92	KMZ-T	Jul	0.70	0.31	0	0	0	674	0.00000000	0.00000000	0.00000000	0.0
92	KMZ-T	Aug	0.78	0.31	0	0	0	666	0.00000000	0.00000000	0.00000000	0.0
92	KMZ-S	May	1.00	—	0	0	0	682	0.00000000	0.00000000	0.00000000	0.0
92	KMZ-S	Jun	1.00	—	0	0	0	682	0.00000000	0.00000000	0.00000000	0.0
92	KMZ-S	Jul	1.00	—	0	0	0	674	0.00000000	0.00000000	0.00000000	21.9
92	KMZ-S	Aug	1.00	—	0	0	0	666	0.00000000	0.00000000	0.00000000	0.0
92	FTB	May	0.57	0.31	0	0	0	682	0.00000000	0.00000000	0.00000000	0.0
92	FTB	Jun	0.62	0.31	0	0	0	682	0.00000000	0.00000000	0.00000000	0.0
92	FTB	Jul	0.70	0.31	0	0	0	674	0.00000000	0.00000000	0.00000000	0.0
92	FTB	Aug	0.78	0.31	0	0	0	666	0.00000000	0.00000000	0.00000000	0.0
92	SOC	May	0.57	0.31	0	0	0	682	0.00000000	0.00000000	0.00000000	5.9
92	SOC	Jun	0.62	0.31	0	0	0	682	0.00000000	0.00000000	0.00000000	3.3
92	SOC	Jul	0.70	0.31	0	0	0	674	0.00000000	0.00000000	0.00000000	2.8
92	SOC	Aug	0.78	0.31	0	0	0	666	0.00000000	0.00000000	0.00000000	4.6
93	NOR	May	0.57	0.31	0	0	0	3449	0.00000000	0.00000000	0.00000000	1.5
93	NOR	Jun	0.62	0.31	6	4	5	3393	0.00190123	0.00117876	0.00140273	1.2
93	NOR	Jul	0.70	0.31	4	3	3	3379	0.00126830	0.00088781	0.00100576	1.7
93	NOR	Aug	0.78	0.31	24	19	21	3313	0.00735151	0.00573418	0.00623555	1.0
93	CSB	May	0.57	0.31	0	0	0	3449	0.00000000	0.00000000	0.00000000	0.6
93	CSB	Jun	0.62	0.31	0	0	0	3393	0.00000000	0.00000000	0.00000000	0.2
93	CSB	Jul	0.70	0.31	0	0	0	3379	0.00000000	0.00000000	0.00000000	0.0
93	CSB	Aug	0.78	0.31	0	0	0	3313	0.00000000	0.00000000	0.00000000	0.0

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Age 3

CY	Area	Month	p	r	C	H	I	N	c	h	i	f
93	KMZ-T	May	0.57	0.31	0	0	0	3449	0.00000000	0.00000000	0.00000000	0.0
93	KMZ-T	Jun	0.62	0.31	0	0	0	3393	0.00000000	0.00000000	0.00000000	0.0
93	KMZ-T	Jul	0.70	0.31	0	0	0	3379	0.00000000	0.00000000	0.00000000	0.0
93	KMZ-T	Aug	0.78	0.31	0	0	0	3313	0.00000000	0.00000000	0.00000000	0.0
93	KMZ-S	May	1.00	—	4	4	4	3449	0.00115969	0.00115969	0.00115969	4.3
93	KMZ-S	Jun	1.00	—	0	0	0	3393	0.00000000	0.00000000	0.00000000	7.9
93	KMZ-S	Jul	1.00	—	9	9	9	3379	0.00266342	0.00266342	0.00266342	19.2
93	KMZ-S	Aug	1.00	—	10	10	10	3313	0.00301799	0.00301799	0.00301799	19.9
93	FTB	May	0.57	0.31	0	0	0	3449	0.00000000	0.00000000	0.00000000	0.1
93	FTB	Jun	0.62	0.31	0	0	0	3393	0.00000000	0.00000000	0.00000000	0.0
93	FTB	Jul	0.70	0.31	17	12	14	3379	0.00507319	0.00355123	0.00402304	0.0
93	FTB	Aug	0.78	0.31	0	0	0	3313	0.00000000	0.00000000	0.00000000	0.0
93	SOC	May	0.57	0.31	74	42	52	3449	0.02136263	0.01217670	0.01502434	9.2
93	SOC	Jun	0.62	0.31	13	8	10	3393	0.00380246	0.00235753	0.00280546	4.0
93	SOC	Jul	0.70	0.31	50	35	40	3379	0.01479680	0.01035776	0.01173387	5.7
93	SOC	Aug	0.78	0.31	173	135	147	3313	0.05223442	0.04074285	0.04430523	4.4
94	NOR	May	0.57	0.31	0	0	0	2493	0.00000000	0.00000000	0.00000000	0.8
94	NOR	Jun	0.62	0.31	0	0	0	2493	0.00000000	0.00000000	0.00000000	0.9
94	NOR	Jul	0.70	0.31	0	0	0	2436	0.00000000	0.00000000	0.00000000	0.0
94	NOR	Aug	0.78	0.31	0	0	0	2383	0.00000000	0.00000000	0.00000000	0.0
94	CSB	May	0.57	0.31	0	0	0	2493	0.00000000	0.00000000	0.00000000	0.1
94	CSB	Jun	0.62	0.31	0	0	0	2493	0.00000000	0.00000000	0.00000000	0.3
94	CSB	Jul	0.70	0.31	0	0	0	2436	0.00000000	0.00000000	0.00000000	0.0
94	CSB	Aug	0.78	0.31	0	0	0	2383	0.00000000	0.00000000	0.00000000	0.0
94	KMZ-T	May	0.57	0.31	0	0	0	2493	0.00000000	0.00000000	0.00000000	0.0
94	KMZ-T	Jun	0.62	0.31	0	0	0	2493	0.00000000	0.00000000	0.00000000	0.0
94	KMZ-T	Jul	0.70	0.31	0	0	0	2436	0.00000000	0.00000000	0.00000000	0.0
94	KMZ-T	Aug	0.78	0.31	3	2	2	2383	0.00107601	0.00083929	0.00091267	0.1
94	KMZ-S	May	1.00	—	0	0	0	2493	0.00000000	0.00000000	0.00000000	14.0
94	KMZ-S	Jun	1.00	—	4	4	4	2493	0.00160476	0.00160476	0.00160476	5.3
94	KMZ-S	Jul	1.00	—	0	0	0	2436	0.00000000	0.00000000	0.00000000	0.0
94	KMZ-S	Aug	1.00	—	6	6	6	2383	0.00251786	0.00251786	0.00251786	4.2
94	FTB	May	0.57	0.31	0	0	0	2493	0.00000000	0.00000000	0.00000000	0.0
94	FTB	Jun	0.62	0.31	0	0	0	2493	0.00000000	0.00000000	0.00000000	0.0
94	FTB	Jul	0.70	0.31	0	0	0	2436	0.00000000	0.00000000	0.00000000	0.0
94	FTB	Aug	0.78	0.31	0	0	0	2383	0.00000000	0.00000000	0.00000000	0.0
94	SOC	May	0.57	0.31	0	0	0	2493	0.00000000	0.00000000	0.00000000	6.5
94	SOC	Jun	0.62	0.31	71	44	52	2493	0.02847163	0.01765241	0.02100637	4.6
94	SOC	Jul	0.70	0.31	67	47	53	2436	0.02756029	0.01929221	0.02185531	5.4
94	SOC	Aug	0.78	0.31	41	32	35	2383	0.01721616	0.01342860	0.01460275	2.4
95	NOR	May	0.57	0.31	9	5	6	14063	0.00062375	0.00035554	0.00043868	0.7
95	NOR	Jun	0.62	0.31	0	0	0	13989	0.00000000	0.00000000	0.00000000	1.1
95	NOR	Jul	0.70	0.31	0	0	0	13751	0.00000000	0.00000000	0.00000000	0.0
95	NOR	Aug	0.78	0.31	428	334	363	13526	0.03165895	0.02469398	0.02685312	2.2
95	CSB	May	0.57	0.31	0	0	0	14063	0.00000000	0.00000000	0.00000000	0.2
95	CSB	Jun	0.62	0.31	16	10	12	13989	0.00115299	0.00071485	0.00085067	0.5
95	CSB	Jul	0.70	0.31	0	0	0	13751	0.00000000	0.00000000	0.00000000	0.0
95	CSB	Aug	0.78	0.31	18	14	15	13526	0.00132702	0.00103508	0.00112558	0.5
95	KMZ-T	May	0.57	0.31	0	0	0	14063	0.00000000	0.00000000	0.00000000	0.0
95	KMZ-T	Jun	0.62	0.31	0	0	0	13989	0.00000000	0.00000000	0.00000000	0.0
95	KMZ-T	Jul	0.70	0.31	0	0	0	13751	0.00000000	0.00000000	0.00000000	0.0
95	KMZ-T	Aug	0.78	0.31	0	0	0	13526	0.00000000	0.00000000	0.00000000	0.0
95	KMZ-S	May	1.00	—	4	4	4	14063	0.00028443	0.00028443	0.00028443	6.5
95	KMZ-S	Jun	1.00	—	13	13	13	13989	0.00092931	0.00092931	0.00092931	18.0
95	KMZ-S	Jul	1.00	—	0	0	0	13751	0.00000000	0.00000000	0.00000000	0.0
95	KMZ-S	Aug	1.00	—	12	12	12	13526	0.00088721	0.00088721	0.00088721	4.6
95	FTB	May	0.57	0.31	0	0	0	14063	0.00000000	0.00000000	0.00000000	0.0
95	FTB	Jun	0.62	0.31	60	37	44	13989	0.00426605	0.00264495	0.00314749	0.0
95	FTB	Jul	0.70	0.31	0	0	0	13751	0.00000000	0.00000000	0.00000000	0.0
95	FTB	Aug	0.78	0.31	5	4	4	13526	0.00037915	0.00029574	0.00032159	0.0
95	SOC	May	0.57	0.31	91	52	64	14063	0.00648699	0.00369758	0.00456230	8.5
95	SOC	Jun	0.62	0.31	229	142	169	13989	0.01637241	0.01015090	0.01207957	5.2

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Age 3

CY	Area	Month	<i>p</i>	<i>r</i>	<i>C</i>	<i>H</i>	<i>I</i>	<i>N</i>	<i>c</i>	<i>h</i>	<i>i</i>	<i>f</i>
95	SOC	Jul	0.70	0.31	284	199	225	13751	0.02067382	0.01447167	0.01639434	5.6
95	SOC	Aug	0.78	0.31	12	9	10	13526	0.00085309	0.00066541	0.00072359	3.2

Table 7: Age 4 CWT contact rates (c), harvest rates (h), impact rates (i), and fishing effort (f), calendar years (CY) 1986–1996 (1996 estimates are preliminary). Estimated rates are area-month specific. Corresponding proportion legal size p and shaker mortality rate r are listed. The numerators for the c , h , and i estimates are given under C , H , and I , respectively. These are all equivalent for age 4 fish because $p = 1$ (and hence the value of r is immaterial: $r = “.”$) for all areas. The denominator in each case is N . See text for explanation of calculations. Fishing effort is in terms of 1000's of days fished for the troll fishery (PFMC, 1997, Tables A-2, A-7, A-20), and 1000's of angler trips for the KMZ-S (PFMC, 1997, Table A-22).

Age 4												
CY	Area	Month	p	r	C	H	I	N	c	h	i	f
86	NOR	May	1	—	9	9	9	3623	0.00248413	0.00248413	0.00248413	0.9
86	NOR	Jun	1	—	0	0	0	3304	0.00000000	0.00000000	0.00000000	0.8
86	NOR	Jul	1	—	0	0	0	2621	0.00000000	0.00000000	0.00000000	8.2
86	NOR	Aug	1	—	0	0	0	2137	0.00000000	0.00000000	0.00000000	0.7
86	CSB	May	1	—	8	8	8	3623	0.00220811	0.00220811	0.00220811	2.1
86	CSB	Jun	1	—	15	15	15	3304	0.00453995	0.00453995	0.00453995	2.4
86	CSB	Jul	1	—	285	285	285	2621	0.10873712	0.10873712	0.10873712	5.6
86	CSB	Aug	1	—	74	74	74	2137	0.03462798	0.03462798	0.03462798	4.2
86	KMZ-T	May	1	—	11	11	11	3623	0.00303616	0.00303616	0.00303616	0.5
86	KMZ-T	Jun	1	—	117	117	117	3304	0.03541162	0.03541162	0.03541162	1.6
86	KMZ-T	Jul	1	—	64	64	64	2621	0.02441816	0.02441816	0.02441816	1.7
86	KMZ-T	Aug	1	—	78	78	78	2137	0.03649977	0.03649977	0.03649977	2.6
86	KMZ-S	May	1	—	2	2	2	3623	0.00055203	0.00055203	0.00055203	5.8
86	KMZ-S	Jun	1	—	0	0	0	3304	0.00000000	0.00000000	0.00000000	25.2
86	KMZ-S	Jul	1	—	17	17	17	2621	0.00648607	0.00648607	0.00648607	33.8
86	KMZ-S	Aug	1	—	18	18	18	2137	0.00842302	0.00842302	0.00842302	26.6
86	FTB	May	1	—	221	221	221	3623	0.06099917	0.06099917	0.06099917	3.4
86	FTB	Jun	1	—	230	230	230	3304	0.06961259	0.06961259	0.06961259	3.4
86	FTB	Jul	1	—	58	58	58	2621	0.02212896	0.02212896	0.02212896	4.4
86	FTB	Aug	1	—	5	5	5	2137	0.00233973	0.00233973	0.00233973	3.1
86	SOC	May	1	—	68	68	68	3623	0.01876898	0.01876898	0.01876898	10.6
86	SOC	Jun	1	—	321	321	321	3304	0.09715496	0.09715496	0.09715496	9.8
86	SOC	Jul	1	—	60	60	60	2621	0.02289203	0.02289203	0.02289203	9.5
86	SOC	Aug	1	—	0	0	0	2137	0.00000000	0.00000000	0.00000000	5.1
87	NOR	May	1	—	12	12	12	16174	0.00074193	0.00074193	0.00074193	1.1
87	NOR	Jun	1	—	6	6	6	14923	0.00040206	0.00040206	0.00040206	1.2
87	NOR	Jul	1	—	201	201	201	12017	0.01672630	0.01672630	0.01672630	5.7
87	NOR	Aug	1	—	109	109	109	8304	0.01312620	0.01312620	0.01312620	3.7
87	CSB	May	1	—	93	93	93	16174	0.00574997	0.00574997	0.00574997	1.7
87	CSB	Jun	1	—	161	161	161	14923	0.01078872	0.01078872	0.01078872	1.7
87	CSB	Jul	1	—	2766	2766	2766	12017	0.23017392	0.23017392	0.23017392	10.3
87	CSB	Aug	1	—	452	452	452	8304	0.05443160	0.05443160	0.05443160	3.5
87	KMZ-T	May	1	—	140	140	140	16174	0.00865587	0.00865587	0.00865587	0.5
87	KMZ-T	Jun	1	—	1135	1135	1135	14923	0.07605709	0.07605709	0.07605709	3.2
87	KMZ-T	Jul	1	—	0	0	0	12017	0.00000000	0.00000000	0.00000000	0.9
87	KMZ-T	Aug	1	—	0	0	0	8304	0.00000000	0.00000000	0.00000000	0.0
87	KMZ-S	May	1	—	4	4	4	16174	0.00024731	0.00024731	0.00024731	6.0
87	KMZ-S	Jun	1	—	61	61	61	14923	0.00408765	0.00408765	0.00408765	33.3
87	KMZ-S	Jul	1	—	77	77	77	12017	0.00640759	0.00640759	0.00640759	55.8
87	KMZ-S	Aug	1	—	135	135	135	8304	0.01625723	0.01625723	0.01625723	35.7
87	FTB	May	1	—	625	625	625	16174	0.03864227	0.03864227	0.03864227	3.8
87	FTB	Jun	1	—	989	989	989	14923	0.06627354	0.06627354	0.06627354	4.9
87	FTB	Jul	1	—	572	572	572	12017	0.04759923	0.04759923	0.04759923	6.8
87	FTB	Aug	1	—	110	110	110	8304	0.01324663	0.01324663	0.01324663	4.1
87	SOC	May	1	—	377	377	377	16174	0.02330901	0.02330901	0.02330901	11.1
87	SOC	Jun	1	—	554	554	554	14923	0.03712390	0.03712390	0.03712390	8.9
87	SOC	Jul	1	—	97	97	97	12017	0.00807190	0.00807190	0.00807190	8.1
87	SOC	Aug	1	—	75	75	75	8304	0.00903179	0.00903179	0.00903179	5.2
88	NOR	May	1	—	6	6	6	10817	0.00055468	0.00055468	0.00055468	1.1
88	NOR	Jun	1	—	25	25	25	9691	0.00257971	0.00257971	0.00257971	1.7
88	NOR	Jul	1	—	114	114	114	7696	0.01481289	0.01481289	0.01481289	9.3
88	NOR	Aug	1	—	60	60	60	6304	0.00951777	0.00951777	0.00951777	6.9
88	CSB	May	1	—	134	134	134	10817	0.01238791	0.01238791	0.01238791	3.2
88	CSB	Jun	1	—	158	158	158	9691	0.01630379	0.01630379	0.01630379	4.4
88	CSB	Jul	1	—	105	105	105	7696	0.01364345	0.01364345	0.01364345	7.7

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88	CSB	Aug	1	-	328	328	328	6304	0.05203046	0.05203046	0.05203046	7.1
88	KMZ-T	May	1	-	112	112	112	10817	0.01035407	0.01035407	0.01035407	0.3
88	KMZ-T	Jun	1	-	531	531	531	9691	0.05479311	0.05479311	0.05479311	1.7
88	KMZ-T	Jul	1	-	0	0	0	7696	0.00000000	0.00000000	0.00000000	0.7
88	KMZ-T	Aug	1	-	0	0	0	6304	0.00000000	0.00000000	0.00000000	0.0
88	KMZ-S	May	1	-	3	3	3	10817	0.00027734	0.00027734	0.00027734	4.7
88	KMZ-S	Jun	1	-	54	54	54	9691	0.00557218	0.00557218	0.00557218	34.2
88	KMZ-S	Jul	1	-	71	71	71	7696	0.00922557	0.00922557	0.00922557	51.9
88	KMZ-S	Aug	1	-	28	28	28	6304	0.00444162	0.00444162	0.00444162	24.0
88	FTB	May	1	-	611	611	611	10817	0.05648516	0.05648516	0.05648516	4.6
88	FTB	Jun	1	-	588	588	588	9691	0.06067485	0.06067485	0.06067485	4.9
88	FTB	Jul	1	-	693	693	693	7696	0.09004678	0.09004678	0.09004678	7.1
88	FTB	Aug	1	-	0	0	0	6304	0.00000000	0.00000000	0.00000000	5.5
88	SOC	May	1	-	260	260	260	10817	0.02403624	0.02403624	0.02403624	12.3
88	SOC	Jun	1	-	639	639	639	9691	0.06593747	0.06593747	0.06593747	14.3
88	SOC	Jul	1	-	409	409	409	7696	0.05314449	0.05314449	0.05314449	12.8
88	SOC	Aug	1	-	0	0	0	6304	0.00000000	0.00000000	0.00000000	7.1
89	NOR	May	1	-	30	30	30	8445	0.00355240	0.00355240	0.00355240	1.4
89	NOR	Jun	1	-	45	45	45	7536	0.00597134	0.00597134	0.00597134	2.5
89	NOR	Jul	1	-	29	29	29	6181	0.00469180	0.00469180	0.00469180	7.3
89	NOR	Aug	1	-	6	6	6	5051	0.00118788	0.00118788	0.00118788	2.9
89	CSB	May	1	-	648	648	648	8445	0.07673179	0.07673179	0.07673179	4.5
89	CSB	Jun	1	-	527	527	527	7536	0.06993100	0.06993100	0.06993100	4.2
89	CSB	Jul	1	-	117	117	117	6181	0.01892898	0.01892898	0.01892898	6.4
89	CSB	Aug	1	-	262	262	262	5051	0.05187092	0.05187092	0.05187092	4.9
89	KMZ-T	May	1	-	5	5	5	8445	0.00059207	0.00059207	0.00059207	0.2
89	KMZ-T	Jun	1	-	489	489	489	7536	0.06488854	0.06488854	0.06488854	1.2
89	KMZ-T	Jul	1	-	0	0	0	6181	0.00000000	0.00000000	0.00000000	0.0
89	KMZ-T	Aug	1	-	30	30	30	5051	0.00593942	0.00593942	0.00593942	0.6
89	KMZ-S	May	1	-	16	16	16	8445	0.00189461	0.00189461	0.00189461	6.5
89	KMZ-S	Jun	1	-	60	60	60	7536	0.00796178	0.00796178	0.00796178	34.2
89	KMZ-S	Jul	1	-	437	437	437	6181	0.07070053	0.07070053	0.07070053	66.6
89	KMZ-S	Aug	1	-	136	136	136	5051	0.02692536	0.02692536	0.02692536	28.6
89	FTB	May	1	-	17	17	17	8445	0.00201303	0.00201303	0.00201303	1.1
89	FTB	Jun	1	-	69	69	69	7536	0.00915605	0.00915605	0.00915605	2.7
89	FTB	Jul	1	-	488	488	488	6181	0.07895163	0.07895163	0.07895163	4.4
89	FTB	Aug	1	-	200	200	200	5051	0.03959612	0.03959612	0.03959612	4.9
89	SOC	May	1	-	193	193	193	8445	0.02285376	0.02285376	0.02285376	12.9
89	SOC	Jun	1	-	165	165	165	7536	0.02189490	0.02189490	0.02189490	12.2
89	SOC	Jul	1	-	59	59	59	6181	0.00954538	0.00954538	0.00954538	7.4
89	SOC	Aug	1	-	16	16	16	5051	0.00316769	0.00316769	0.00316769	6.8
90	NOR	May	1	-	0	0	0	1792	0.00000000	0.00000000	0.00000000	0.6
90	NOR	Jun	1	-	6	6	6	1687	0.00355661	0.00355661	0.00355661	1.5
90	NOR	Jul	1	-	40	40	40	1447	0.02764340	0.02764340	0.02764340	4.0
90	NOR	Aug	1	-	0	0	0	779	0.00000000	0.00000000	0.00000000	2.0
90	CSB	May	1	-	48	48	48	1792	0.02678571	0.02678571	0.02678571	2.2
90	CSB	Jun	1	-	34	34	34	1687	0.02015412	0.02015412	0.02015412	2.2
90	CSB	Jul	1	-	542	542	542	1447	0.37456807	0.37456807	0.37456807	6.4
90	CSB	Aug	1	-	219	219	219	779	0.28112965	0.28112965	0.28112965	3.6
90	KMZ-T	May	1	-	0	0	0	1792	0.00000000	0.00000000	0.00000000	0.0
90	KMZ-T	Jun	1	-	0	0	0	1687	0.00000000	0.00000000	0.00000000	0.0
90	KMZ-T	Jul	1	-	0	0	0	1447	0.00000000	0.00000000	0.00000000	0.0
90	KMZ-T	Aug	1	-	35	35	35	779	0.04492940	0.04492940	0.04492940	1.1
90	KMZ-S	May	1	-	0	0	0	1792	0.00000000	0.00000000	0.00000000	3.5
90	KMZ-S	Jun	1	-	28	28	28	1687	0.01659751	0.01659751	0.01659751	40.8
90	KMZ-S	Jul	1	-	46	46	46	1447	0.03178991	0.03178991	0.03178991	65.8
90	KMZ-S	Aug	1	-	4	4	4	779	0.00513479	0.00513479	0.00513479	20.1
90	FTB	May	1	-	9	9	9	1792	0.00502232	0.00502232	0.00502232	0.9
90	FTB	Jun	1	-	118	118	118	1687	0.06994665	0.06994665	0.06994665	3.6
90	FTB	Jul	1	-	32	32	32	1447	0.02211472	0.02211472	0.02211472	3.0
90	FTB	Aug	1	-	2	2	2	779	0.00256739	0.00256739	0.00256739	1.5
90	SOC	May	1	-	48	48	48	1792	0.02678571	0.02678571	0.02678571	11.8

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90	SOC	Jun	1	-	54	54	54	1687	0.03200948	0.03200948	0.03200948	11.6
90	SOC	Jul	1	-	8	8	8	1447	0.00552868	0.00552868	0.00552868	8.9
90	SOC	Aug	1	-	0	0	0	779	0.00000000	0.00000000	0.00000000	3.3
91	NOR	May	1	-	2	2	2	1009	0.00198216	0.00198216	0.00198216	0.7
91	NOR	Jun	1	-	0	0	0	980	0.00000000	0.00000000	0.00000000	2.1
91	NOR	Jul	1	-	0	0	0	897	0.00000000	0.00000000	0.00000000	2.6
91	NOR	Aug	1	-	5	5	5	869	0.00575374	0.00575374	0.00575374	1.0
91	CSB	May	1	-	0	0	0	1009	0.00000000	0.00000000	0.00000000	0.0
91	CSB	Jun	1	-	3	3	3	980	0.00306122	0.00306122	0.00306122	1.8
91	CSB	Jul	1	-	8	8	8	897	0.00891862	0.00891862	0.00891862	1.5
91	CSB	Aug	1	-	14	14	14	869	0.01611047	0.01611047	0.01611047	1.0
91	KMZ-T	May	1	-	0	0	0	1009	0.00000000	0.00000000	0.00000000	0.0
91	KMZ-T	Jun	1	-	0	0	0	980	0.00000000	0.00000000	0.00000000	0.0
91	KMZ-T	Jul	1	-	0	0	0	897	0.00000000	0.00000000	0.00000000	0.0
91	KMZ-T	Aug	1	-	0	0	0	869	0.00000000	0.00000000	0.00000000	0.0
91	KMZ-S	May	1	-	0	0	0	1009	0.00000000	0.00000000	0.00000000	2.1
91	KMZ-S	Jun	1	-	36	36	36	980	0.03673469	0.03673469	0.03673469	33.3
91	KMZ-S	Jul	1	-	0	0	0	897	0.00000000	0.00000000	0.00000000	44.9
91	KMZ-S	Aug	1	-	0	0	0	869	0.00000000	0.00000000	0.00000000	2.9
91	FTB	May	1	-	0	0	0	1009	0.00000000	0.00000000	0.00000000	0.0
91	FTB	Jun	1	-	4	4	4	980	0.00408163	0.00408163	0.00408163	0.0
91	FTB	Jul	1	-	2	2	2	897	0.00222965	0.00222965	0.00222965	0.0
91	FTB	Aug	1	-	60	60	60	869	0.06904488	0.06904488	0.06904488	3.5
91	SOC	May	1	-	27	27	27	1009	0.02675917	0.02675917	0.02675917	8.4
91	SOC	Jun	1	-	40	40	40	980	0.04081633	0.04081633	0.04081633	10.9
91	SOC	Jul	1	-	18	18	18	897	0.02006689	0.02006689	0.02006689	6.4
91	SOC	Aug	1	-	24	24	24	869	0.02761795	0.02761795	0.02761795	3.6
92	NOR	May	1	-	6	6	6	881	0.00681044	0.00681044	0.00681044	1.5
92	NOR	Jun	1	-	0	0	0	875	0.00000000	0.00000000	0.00000000	0.0
92	NOR	Jul	1	-	6	6	6	872	0.00688073	0.00688073	0.00688073	1.3
92	NOR	Aug	1	-	37	37	37	864	0.04282407	0.04282407	0.04282407	2.5
92	CSB	May	1	-	0	0	0	881	0.00000000	0.00000000	0.00000000	0.1
92	CSB	Jun	1	-	3	3	3	875	0.00342857	0.00342857	0.00342857	0.0
92	CSB	Jul	1	-	0	0	0	872	0.00000000	0.00000000	0.00000000	0.1
92	CSB	Aug	1	-	4	4	4	864	0.00462963	0.00462963	0.00462963	0.2
92	KMZ-T	May	1	-	0	0	0	881	0.00000000	0.00000000	0.00000000	0.0
92	KMZ-T	Jun	1	-	0	0	0	875	0.00000000	0.00000000	0.00000000	0.0
92	KMZ-T	Jul	1	-	0	0	0	872	0.00000000	0.00000000	0.00000000	0.0
92	KMZ-T	Aug	1	-	0	0	0	864	0.00000000	0.00000000	0.00000000	0.0
92	KMZ-S	May	1	-	0	0	0	881	0.00000000	0.00000000	0.00000000	0.0
92	KMZ-S	Jun	1	-	0	0	0	875	0.00000000	0.00000000	0.00000000	0.0
92	KMZ-S	Jul	1	-	0	0	0	872	0.00000000	0.00000000	0.00000000	21.9
92	KMZ-S	Aug	1	-	0	0	0	864	0.00000000	0.00000000	0.00000000	0.0
92	FTB	May	1	-	0	0	0	881	0.00000000	0.00000000	0.00000000	0.0
92	FTB	Jun	1	-	0	0	0	875	0.00000000	0.00000000	0.00000000	0.0
92	FTB	Jul	1	-	2	2	2	872	0.00229358	0.00229358	0.00229358	0.0
92	FTB	Aug	1	-	0	0	0	864	0.00000000	0.00000000	0.00000000	0.0
92	SOC	May	1	-	0	0	0	881	0.00000000	0.00000000	0.00000000	5.9
92	SOC	Jun	1	-	0	0	0	875	0.00000000	0.00000000	0.00000000	3.3
92	SOC	Jul	1	-	0	0	0	872	0.00000000	0.00000000	0.00000000	2.8
92	SOC	Aug	1	-	8	8	8	864	0.00925926	0.00925926	0.00925926	4.6
93	NOR	May	1	-	9	9	9	299	0.03010033	0.03010033	0.03010033	1.5
93	NOR	Jun	1	-	9	9	9	272	0.03308824	0.03308824	0.03308824	1.2
93	NOR	Jul	1	-	0	0	0	263	0.00000000	0.00000000	0.00000000	1.7
93	NOR	Aug	1	-	10	10	10	254	0.03937008	0.03937008	0.03937008	1.0
93	CSB	May	1	-	0	0	0	299	0.00000000	0.00000000	0.00000000	0.6
93	CSB	Jun	1	-	0	0	0	272	0.00000000	0.00000000	0.00000000	0.2
93	CSB	Jul	1	-	2	2	2	263	0.00760456	0.00760456	0.00760456	0.0
93	CSB	Aug	1	-	0	0	0	254	0.00000000	0.00000000	0.00000000	0.0
93	KMZ-T	May	1	-	0	0	0	299	0.00000000	0.00000000	0.00000000	0.0
93	KMZ-T	Jun	1	-	0	0	0	272	0.00000000	0.00000000	0.00000000	0.0
93	KMZ-T	Jul	1	-	0	0	0	263	0.00000000	0.00000000	0.00000000	0.0

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93	KMZ-T	Aug	1	-	0	0	0	254	0.00000000	0.00000000	0.00000000	0.0
93	KMZ-S	May	1	-	0	0	0	299	0.00000000	0.00000000	0.00000000	4.3
93	KMZ-S	Jun	1	-	0	0	0	272	0.00000000	0.00000000	0.00000000	7.9
93	KMZ-S	Jul	1	-	0	0	0	263	0.00000000	0.00000000	0.00000000	19.2
93	KMZ-S	Aug	1	-	0	0	0	254	0.00000000	0.00000000	0.00000000	19.9
93	FTB	May	1	-	0	0	0	299	0.00000000	0.00000000	0.00000000	0.1
93	FTB	Jun	1	-	0	0	0	272	0.00000000	0.00000000	0.00000000	0.0
93	FTB	Jul	1	-	0	0	0	263	0.00000000	0.00000000	0.00000000	0.0
93	FTB	Aug	1	-	0	0	0	254	0.00000000	0.00000000	0.00000000	0.0
93	SOC	May	1	-	18	18	18	299	0.06020067	0.06020067	0.06020067	9.2
93	SOC	Jun	1	-	0	0	0	272	0.00000000	0.00000000	0.00000000	4.0
93	SOC	Jul	1	-	7	7	7	263	0.02661597	0.02661597	0.02661597	5.7
93	SOC	Aug	1	-	33	33	33	254	0.12992126	0.12992126	0.12992126	4.4
94	NOR	May	1	-	8	8	8	1461	0.00547570	0.00547570	0.00547570	0.8
94	NOR	Jun	1	-	8	8	8	1408	0.00568182	0.00568182	0.00568182	0.9
94	NOR	Jul	1	-	0	0	0	1351	0.00000000	0.00000000	0.00000000	0.0
94	NOR	Aug	1	-	0	0	0	1316	0.00000000	0.00000000	0.00000000	0.0
94	CSB	May	1	-	0	0	0	1461	0.00000000	0.00000000	0.00000000	0.1
94	CSB	Jun	1	-	0	0	0	1408	0.00000000	0.00000000	0.00000000	0.3
94	CSB	Jul	1	-	0	0	0	1351	0.00000000	0.00000000	0.00000000	0.0
94	CSB	Aug	1	-	0	0	0	1316	0.00000000	0.00000000	0.00000000	0.0
94	KMZ-T	May	1	-	0	0	0	1461	0.00000000	0.00000000	0.00000000	0.0
94	KMZ-T	Jun	1	-	0	0	0	1408	0.00000000	0.00000000	0.00000000	0.0
94	KMZ-T	Jul	1	-	0	0	0	1351	0.00000000	0.00000000	0.00000000	0.0
94	KMZ-T	Aug	1	-	1	1	1	1316	0.00075988	0.00075988	0.00075988	0.1
94	KMZ-S	May	1	-	35	35	35	1461	0.02395619	0.02395619	0.02395619	14.0
94	KMZ-S	Jun	1	-	9	9	9	1408	0.00639205	0.00639205	0.00639205	5.3
94	KMZ-S	Jul	1	-	0	0	0	1351	0.00000000	0.00000000	0.00000000	0.0
94	KMZ-S	Aug	1	-	5	5	5	1316	0.00379939	0.00379939	0.00379939	4.2
94	FTB	May	1	-	6	6	6	1461	0.00410678	0.00410678	0.00410678	0.0
94	FTB	Jun	1	-	14	14	14	1408	0.00994318	0.00994318	0.00994318	0.0
94	FTB	Jul	1	-	0	0	0	1351	0.00000000	0.00000000	0.00000000	0.0
94	FTB	Aug	1	-	3	3	3	1316	0.00227964	0.00227964	0.00227964	0.0
94	SOC	May	1	-	4	4	4	1461	0.00273785	0.00273785	0.00273785	6.5
94	SOC	Jun	1	-	26	26	26	1408	0.01846591	0.01846591	0.01846591	4.6
94	SOC	Jul	1	-	35	35	35	1351	0.02590674	0.02590674	0.02590674	5.4
94	SOC	Aug	1	-	10	10	10	1316	0.00759878	0.00759878	0.00759878	2.4
95	NOR	May	1	-	15	15	15	647	0.02318393	0.02318393	0.02318393	0.7
95	NOR	Jun	1	-	5	5	5	624	0.00801282	0.00801282	0.00801282	1.1
95	NOR	Jul	1	-	0	0	0	596	0.00000000	0.00000000	0.00000000	0.0
95	NOR	Aug	1	-	40	40	40	561	0.07130125	0.07130125	0.07130125	2.2
95	CSB	May	1	-	0	0	0	647	0.00000000	0.00000000	0.00000000	0.2
95	CSB	Jun	1	-	0	0	0	624	0.00000000	0.00000000	0.00000000	0.5
95	CSB	Jul	1	-	0	0	0	596	0.00000000	0.00000000	0.00000000	0.0
95	CSB	Aug	1	-	0	0	0	561	0.00000000	0.00000000	0.00000000	0.5
95	KMZ-T	May	1	-	0	0	0	647	0.00000000	0.00000000	0.00000000	0.0
95	KMZ-T	Jun	1	-	0	0	0	624	0.00000000	0.00000000	0.00000000	0.0
95	KMZ-T	Jul	1	-	0	0	0	596	0.00000000	0.00000000	0.00000000	0.0
95	KMZ-T	Aug	1	-	0	0	0	561	0.00000000	0.00000000	0.00000000	0.0
95	KMZ-S	May	1	-	0	0	0	647	0.00000000	0.00000000	0.00000000	6.5
95	KMZ-S	Jun	1	-	2	2	2	624	0.00320513	0.00320513	0.00320513	18.0
95	KMZ-S	Jul	1	-	0	0	0	596	0.00000000	0.00000000	0.00000000	0.0
95	KMZ-S	Aug	1	-	0	0	0	561	0.00000000	0.00000000	0.00000000	4.6
95	FTB	May	1	-	0	0	0	647	0.00000000	0.00000000	0.00000000	0.0
95	FTB	Jun	1	-	3	3	3	624	0.00480769	0.00480769	0.00480769	0.0
95	FTB	Jul	1	-	0	0	0	596	0.00000000	0.00000000	0.00000000	0.0
95	FTB	Aug	1	-	0	0	0	561	0.00000000	0.00000000	0.00000000	0.0
95	SOC	May	1	-	8	8	8	647	0.01236476	0.01236476	0.01236476	8.5
95	SOC	Jun	1	-	18	18	18	624	0.02884615	0.02884615	0.02884615	5.2
95	SOC	Jul	1	-	35	35	35	596	0.05872483	0.05872483	0.05872483	5.6
95	SOC	Aug	1	-	0	0	0	561	0.00000000	0.00000000	0.00000000	3.2
96	NOR	May	1	-	53	53	53	4710	0.01125265	0.01125265	0.01125265	1.1

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Age 4

CY	Area	Month	<i>p</i>	<i>r</i>	<i>C</i>	<i>H</i>	<i>I</i>	<i>N</i>	<i>c</i>	<i>h</i>	<i>i</i>	<i>f</i>
96	NOR	Jun	1	—	10	10	10	4572	0.00218723	0.00218723	0.00218723	1.4
96	NOR	Jul	1	—	0	0	0	4052	0.00000000	0.00000000	0.00000000	0.0
96	NOR	Aug	1	—	55	55	55	3769	0.01459273	0.01459273	0.01459273	1.5
96	CSB	May	1	—	0	0	0	4710	0.00000000	0.00000000	0.00000000	0.2
96	CSB	Jun	1	—	12	12	12	4572	0.00262467	0.00262467	0.00262467	0.5
96	CSB	Jul	1	—	0	0	0	4052	0.00000000	0.00000000	0.00000000	0.0
96	CSB	Aug	1	—	0	0	0	3769	0.00000000	0.00000000	0.00000000	0.3
96	KMZ-T	May	1	—	0	0	0	4710	0.00000000	0.00000000	0.00000000	1.0
96	KMZ-T	Jun	1	—	12	12	12	4572	0.00262467	0.00262467	0.00262467	0.0
96	KMZ-T	Jul	1	—	0	0	0	4052	0.00000000	0.00000000	0.00000000	0.0
96	KMZ-T	Aug	1	—	8	8	8	3769	0.00212258	0.00212258	0.00212258	0.4
96	KMZ-S	May	1	—	10	10	10	4710	0.00212314	0.00212314	0.00212314	5.1
96	KMZ-S	Jun	1	—	8	8	8	4572	0.00174978	0.00174978	0.00174978	17.5
96	KMZ-S	Jul	1	—	0	0	0	4052	0.00000000	0.00000000	0.00000000	5.6
96	KMZ-S	Aug	1	—	0	0	0	3769	0.00000000	0.00000000	0.00000000	10.8
96	FTB	May	1	—	8	8	8	4710	0.00169851	0.00169851	0.00169851	0.0
96	FTB	Jun	1	—	16	16	16	4572	0.00349956	0.00349956	0.00349956	0.0
96	FTB	Jul	1	—	0	0	0	4052	0.00000000	0.00000000	0.00000000	0.0
96	FTB	Aug	1	—	13	13	13	3769	0.00344919	0.00344919	0.00344919	1.2
96	SOC	May	1	—	67	67	67	4710	0.01422505	0.01422505	0.01422505	4.7
96	SOC	Jun	1	—	462	462	462	4572	0.10104987	0.10104987	0.10104987	5.7
96	SOC	Jul	1	—	283	283	283	4052	0.06984205	0.06984205	0.06984205	5.1
96	SOC	Aug	1	—	9	9	9	3769	0.00238790	0.00238790	0.00238790	1.3

4 Appendix B

Table 8: Age 3 estimated contact rates per unit effort ($\hat{\beta}$) and $ave\{f\}$, by area-month. $\hat{\beta}$ is the ratio estimate and equals $ave\{c\}/ave\{f\}$, these averages taken over the calendar year data given in Appendix 3, Table 6. Preliminary data for CY95 not included in $\hat{\beta}$ and $ave\{f\}$.

Age 3				
Area	Month	$\hat{\beta}$	$ave\{f\}$	
NOR	May	0.000023	1.07	
NOR	Jun	0.000338	1.32	
NOR	Jul	0.000990	4.46	
NOR	Aug	0.001583	2.30	
CSB	May	0.001854	1.61	
CSB	Jun	0.003617	1.91	
CSB	Jul	0.007360	4.22	
CSB	Aug	0.015146	2.72	
KMZ-T	May	0.002408	0.17	
KMZ-T	Jun	0.013078	0.86	
KMZ-T	Jul	0.002609	0.37	
KMZ-T	Aug	0.007721	0.49	
KMZ-S	May	0.000134	5.21	
KMZ-S	Jun	0.000265	23.80	
KMZ-S	Jul	0.000215	39.99	
KMZ-S	Aug	0.000142	18.00	
FTB	May	0.003137	1.54	
FTB	Jun	0.006253	2.17	
FTB	Jul	0.009875	2.86	
FTB	Aug	0.003998	2.51	
SOC	May	0.000797	9.86	
SOC	Jun	0.002047	8.84	
SOC	Jul	0.002067	7.44	
SOC	Aug	0.002305	4.72	

Table 9: Age 4 estimated contact rates per unit effort ($\hat{\beta}$) and $ave\{f\}$, by area-month. $\hat{\beta}$ is the ratio estimate and equals $ave\{c\}/ave\{f\}$, these averages taken over the calendar year data given in Appendix 3, Table 7. Preliminary data for CY96 not included in $\hat{\beta}$ and $ave\{f\}$.

Age 4			
Area	Month	$\hat{\beta}$	$ave\{f\}$
NOR	May	0.007270	1.03
NOR	Jun	0.004561	1.30
NOR	Jul	0.001764	4.01
NOR	Aug	0.007995	2.29
CSB	May	0.008426	1.47
CSB	Jun	0.007243	1.77
CSB	Jul	0.020068	3.80
CSB	Aug	0.019793	2.50
KMZ-T	May	0.015092	0.15
KMZ-T	Jun	0.030020	0.77
KMZ-T	Jul	0.007399	0.33
KMZ-T	Aug	0.020029	0.44
KMZ-S	May	0.000504	5.34
KMZ-S	Jun	0.000347	23.22
KMZ-S	Jul	0.000346	35.99
KMZ-S	Aug	0.000390	16.66
FTB	May	0.012034	1.39
FTB	Jun	0.015102	1.95
FTB	Jul	0.010325	2.57
FTB	Aug	0.005711	2.26
SOC	May	0.002241	9.72
SOC	Jun	0.004036	8.48
SOC	Jul	0.003175	7.26
SOC	Aug	0.004083	4.57

References

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